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VOL. CXXXII.—No. 3443] LONDON: FRIDAY EVENING, DECEMBER 23, 1921 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

The Engineer

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The Buxton Boiler Explosion.

The Disposal of House Refuse.

A 5½ inch Capstan Lathe.

Deep Water Quay Walls.

The Panama Canal Slides.

PUBLIC NOTICES

INDIAN SERVICE OF ENGINEERS AND ENGINEERING ESTABLISHMENT OF INDIAN STATE RAILWAYS.

The Secretary of State for India in Council will in 1922 APPOINT 11 ASSISTANT EXECUTIVE ENGINEERS for these Services if so many suitable candidates present themselves.

Every candidate must be a British subject, or a ruler or subject of any State in India in respect of whom the Governor-General of India in Council has made a declaration that he is to be considered eligible.

The appointments for Europeans will be reserved for candidates who have served in His Majesty's Forces during the war for at least one year, or who have been prevented on adequate grounds from so serving. European candidates must have been born on or after 2nd August, 1896, and on or before 1st August, 1900.

Indian candidates must have attained the age of 21 and not attained the age of 24 years on 1st July, 1922, except that in the case of an Indian who has rendered service of the nature defined in the preceding paragraph, the same maximum age limit as for Europeans will apply. Subject to this exception, the maximum age limit of 24 years for Indian candidates will be maintained for the next year and will be reduced to 23 years in 1923.

Every candidate must either (1) have obtained one of certain recognised university degrees or other distinctions in engineering, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers, or been exempted by the Institution from such examination, or (3) produce the required evidence that he is otherwise eligible under the Regulations.

Applications from candidates must reach the India Office not later than 1st April. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W. 1.

India Office, London,
12th December, 1921. 6902

The High Commissioner for India is prepared to receive TENDERS for the SUPPLY of MILD STEEL PLATES.

Forms of Tender may be obtained from the Director-General, India Store Department, Belvedere-road, Lambeth, S.E. 1, and Tenders are to be delivered at that office not later than Two o'clock p.m. on Thursday, 5th January, 1922.

T. RYAN,
Director-General.

6900

Auckland Harbour Board, New ZEALAND.

TENDERS are INVITED for the SUPPLY and DELIVERY of FOUR (4) DOUBLE-BARREL ELECTRIC WINCHES for Central Wharf, Auckland.

Specifications and forms of Tender may be obtained on payment of a deposit (returnable) of One Guinea at the office of the Board's Agents,

Messrs. W. and A. McArthur, Ltd.,
16/19, Silk-street,
Cripplegate, London, E.C. 2.

Tenders to reach Auckland by Noon on Tuesday, 25th April, 1922, addressed to the CHAIRMAN, Harbour Board, Auckland, New Zealand. 6976

Borough of Stratford-upon-AVON.

The Town Council invite TENDERS for SINKING a BORE HOLE to an approximate depth of 800ft. and PROVIDING and FIXING PUMPING PLANT.

Copies of the specification and Tender form can be obtained on application to the Borough and Water Engineer, Mr. F. W. Jones, Assoc. M. Inst. C.E., Municipal Offices, Stratford-upon-Avon, on payment of a deposit of £2 2s., which will be refunded on receipt of a bona fide Tender, together with all documents required under the specification.

Tenders, sealed "Tender for Bore-hole," to be sent to me not later than Twelve o'clock Noon, February 6th, 1922.

The Corporation give no undertaking to accept either the lowest or any Tender, and any Tender selected will be accepted only subject to the sanction of the Ministry of Health being obtained to the scheme.

ROBERT LUNN,
Town Clerk.

Municipal Offices,
Stratford-upon-Avon,
21st December, 1921. 6991

City of Chichester

WATERWORKS.—CONTRACT No. 1.

The Town Council of the City of Chichester invite TENDERS for the SUPPLY of approximately:—

2400 Yards of 9in. diameter CAST IRON PIPES, and

150 Yards of 12in. diameter CAST IRON PIPES.

(Steel Pipes may be considered as an alternative proposition.)

Specification and conditions can be seen, and forms for tendering can be obtained from the City Engineer, Mr. Frank J. Lobley, A.M.I.C.E., at his office, during the usual office hours, upon payment of a deposit of Two Guineas.

Tenders, in sealed envelopes, endorsed "Waterworks Contract No. 1," to be received not later than 11 a.m. on Monday, the 9th day of January, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

J. W. LOADER COOPER,
Town Clerk.

East-street,
Chichester,
14th December, 1921. 6987

County Borough of Burton-UPON-TRENT.

SEWAGE RISING MAIN.
CONTRACT No. 1A.

TENDERS FOR CAST IRON PIPES.

TENDERS are REQUIRED for the SUPPLY and DELIVERY of about 1050 TONS of 27in., 21in., 18in., and 12in. CAST IRON PIPES and SPECIALS.

Specifications, &c., can be obtained and drawings seen on application to the undersigned, to whom Tenders must be delivered not later than 10 a.m. on Saturday, the 31st December, 1921.

No Tender will be accepted from any party who pays his employees, whether artizans or labourers, less than the standard rate of wages paid in this Borough, or who does not conform to the hours and conditions of labour generally recognised in each branch of industry affected, and clauses to ensure compliance with this regulation are inserted in the general conditions of contract.

The Corporation do not bind themselves to accept the lowest or any Tender, and parties tendering must do so at their own expense.

GEORGE T. LYNAM,
Borough Engineer and Surveyor.

Town Hall, 16th December, 1921. 6906

PUBLIC NOTICES

Chester Waterworks.

SEMI-DIESEL ENGINES.

MAKERS of VERTICAL SEMI-DIESEL ENGINES of 200 B.H.P. are INVITED to SEND their NAMES and ADDRESSES to Mr. C. W. BENNETT, Engineer, Tower Works, Boughton, Chester. 6963

EXTENDED TIME FOR TENDERS.

West Kent Main Sewerage BOARD.

EXTENSION OF MAIN OUTFALL WORKS.

TENDERS are INVITED for the CONSTRUCTION of PRECIPITATION and STORAGE TANKS, SEWERS, BUILDINGS, and other WORKS at Long Reach, Dartford.

Drawings may be seen at the offices of the Consulting Engineer, Sidney R. Lowcock, M. Inst. C.E., 6, Queen Anne's-gate, Westminster, or at the offices of the Board, and a copy of the conditions of contract, specifications, bill of quantities, form of Tender, &c., may be obtained from the undersigned upon payment of a deposit of Five Pounds, which will be returned upon receipt of a bona fide Tender, not afterwards withdrawn.

Tenders, sealed and endorsed "Contract No. 4," must be delivered to me, at the offices of the Board, on or before Twelve Noon, Saturday, the 21st January next.

The Board do not bind themselves to accept the lowest or any Tender

ARTHUR B. COOMBER,
Secretary.

Offices of the Board,
Park House, Bromley, Kent. 6984

SITUATIONS OPEN

ASSISTANT DESIGNER WANTED for Centrifugal and Turbine Pump Work; must also be capable Draughtsman.—Apply, stating age, detailed experience and salary required, to W. H. ALLEN SONS and CO., Ltd., Bedford. 6971 A

CAPABLE CHIEF ENGINEER WANTED, Able to take entire charge of Cotton Seed Crushing Mill in Egypt. Must have very good knowledge and experience with Cotton Seed Crushing, also in Dynamos, Electric Motors, Electrically Driven Machinery, Steam Engines and Boilers with coal and oil fuel. Age 30/35. Well educated, tactful, and man of refined appearance preferred. Give full particulars, stating salary expected.—Address, 6978, The Engineer Office. 6978 A

DEAN, SMITH and GRACE (1908), Ltd., Lathe Manufacturers, Keighley, are OPEN to ENGAGE a First-class SALESMAN. Must have practical experience in the Machine Tool Trade.—Apply by letter, giving experience, &c. 6986 A

ENGINEER REPRESENTATIVE REQUIRED by large manufacturing concern for Birmingham district. Applicants must have thorough engineering experience and good connections in the motor car trade. Please state salary required, full particulars of experience, &c.—Address, P4581, The Engineer Office. P4581 A

ENGINEER WANTED, with Scientific Training, to Manage Manufacturing Engineering Department turning out a range of high-class products. Age preferably not exceeding 28; salary about £500.—Address, giving full details of training and experience, 6987, The Engineer Office. 6987 A

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TRAVELLER REQUIRED, Internal Combustion Engines, Agricultural Machinery and Machine Tools. Commission basis.—Applications, stating district, to PERCY R. CLARK, 26, Charing Cross-road, London, W.C. P4585 A

SITUATIONS OPEN (continued)

WORKS MANAGER, with Ability, REQUIRED for important works with about 1000 employees in normal times, devoted to the production of a high-class engineering specialty. Must have sound experience in controlling staff and be thoroughly conversant with up-to-date machine shop practice for medium and heavy work, including gear cutting of all descriptions. Applicants should be possessed of broad outlook and be capable of obtaining high class production on the most economical lines. Elaborate systems and expensive organisation undesirable. Applications, in strict confidence, stating salary expected, age, and brief outline of experience. Only first-class men who have made a success in a similar position should apply.

Address, "ENGINEERING," Wm. Porteous and Co., Advertising Agents, Glasgow. P4555 A

WANTED, Thoroughly Skilled DRAUGHTSMAN; one with knowledge of Hydraulic Press Work preferred, capable of taking full charge.—Address full particulars, 6944, The Engineer Office. 6944 A

DRAUGHTSMAN, Experienced and Accustomed to Gasworks Plant and Structural Steel Work.—Apply, stating age, experience, and salary required, to General Manager, C. and W. WALKER, Ltd., Midland Ironworks, Donnington, Newport, Salop. 6980 A

DRAUGHTSMAN REQUIRED for Steel Structural Engineering Works, making all kinds steel-framed buildings. Able to do own calculations and detail drawings. Salary £208 per annum.—Address, P4580, The Engineer Office. P4580 A

DRAUGHTSMAN WANTED by Large Firm of Motor Lorry Manufacturers. Should have had at least ten years' experience in chassis work generally and in the design of special units. Should be able to make all usual calculations and execute work accurately and require minimum amount of supervision. One with shop experience preferred.

Give particulars of experience, age and salary required.

Address, P4583, The Engineer Office. P4583 A

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CLERK (Male), Young, for General Work, including shorthand and typewriting. Preferably one with a knowledge of Light Railway Business.—Write, stating age, full particulars, and salary required, to M. 6, care Deacon's, Leadenhall-street, E.C. 3. 6985 A

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HOME STUDENTS.—London Matriculation, B.Sc., and A.M.I.C.E. Exams. During studies difficulties arise. Correspondence classes are expensive and possibly you only require occasional individual explanations. We offer you these. Send stamp for particulars.—CONSULTATORS, 60, Abingdon-road, Kensington, London, W. P4588 E

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MISCELLANEOUS

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MISCELLANEOUS

CATALOGUES, TECHNICAL PAPERS, INSTRUCTION MANUALS, &c.

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PATENTS

THE PROPRIETOR of BRITISH PATENT No. 146,280, dated January 13th, 1917, relating to "CANE CRUSHING MILLS," is DESIROUS of ENTERING into ARRANGEMENTS by way of LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above PATENT and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois. 6926 H

THE PROPRIETOR of BRITISH PATENT No. 30,057/13, dated December 31, 1913, relating to "Improvements in Means for Admitting Air or Fuel to the Induction Pipes of Internal Combustion Engines," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above Patent and ensuring its practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois. 6974 H

THE PROPRIETOR of BRITISH PATENTS Nos. 115,396 and 122,488, both dated January 25, 1918, relating to "Valve Mechanism for Internal Combustion Engines" and "Internal Combustion Engine," is DESIROUS of ENTERING into ARRANGEMENTS by way of a LICENCE or otherwise on reasonable terms for the purpose of EXPLOITING the above Patents and ensuring their practical workings in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building, Chicago, Illinois. 6975 H

THE PROPRIETOR of LETTERS PATENT No. 122,181 and 122,182, relating to
"PERCUSSION FUSES FOR PROJECTILES,"
DESIRES to DISPOSE of his PATENTS or to GRANT LICENCES to interested parties on reasonable terms with a view to the adequate working of the patent in this country.—Inquiries to be addressed to
CRUIKSHANK and FAIRWEATHER,
65-66, Chancery-lane, London, W.C. 2.
6981 H

FOR HIRE

FOR HIRE, PUMPS and WELL-BORING TOOLS for Contractors' Deep Wells, &c., 2in. to 24in. dia.—E. RICHARDS and CO., Upper Ground-street, London, S.E. Telephone No. 978 Hop. 822 C

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WANTED, 130/150 B.H.P. GAS ENGINE, by good maker, for suction gas plant.—Address all particulars, including maker's name, engine number, when new, where to be seen, and lowest price f.o.r., P4584, The Engineer Office. P4584 F

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For continuation of Small Advertisements see page xcvi

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Institution of Mechanical Engineers

CONVEYING AND ELEVATING MACHINERY.

THE Institution of Mechanical Engineers met at Storey's Gate on Friday, December 16th, to discuss two papers on allied subjects. The first, on "Conveying and Elevating Machinery," was presented by Mr. Gardiner Mitchell, of Aberdeen, while the second, by Mr. R. E. Knight, of London, which we reprint on page 685, dealt with the "Discharge of Grain Cargoes in the Port of London by Pneumatic Elevators." The chair was taken at the opening of the meeting by the President, Captain Riall Sankey, who, however, had to leave at 7 o'clock, when Dr. Hele-Shaw took his place.

After the usual business had been transacted, the President recalled the discussion, which was carried on early this year, as to the desirability of securing a Royal charter for the Institution, and pointed out that the original memorandum of association had been so wisely drawn up that the members were really in a better position than would be the case if a charter were held. Under the existing conditions the rules of the Institution could be altered without consulting any outside authority, but under a charter any little alteration would have to be referred to several Government departments. There were, however, changes in some of the articles—that, for instance, which says that an associate member is not a member of the Institution—which the Council thought might be made, and several suggestions would be published in the next issue of the *Journal*, while a special meeting would be held on January 20th to discuss the subject, and another on February 17th for balloting purposes.

The President then asked Mr. Mitchell to present his paper. Opening with a few general remarks, in the course of which he said that there was no article of commerce which could not be handled by conveyors, the author then exhibited a large number of lantern slides showing various types of conveyors. Mr. Knight, the author of the second paper, also exhibited a large collection of slides. He pointed out one or two corrections which he wished to make in the printed paper.* In connection with the Dolphins mentioned at the bottom of Table I., he said the motors were really of 200 brake horse-power, and although the illustration of the same elevators showed three suction pipes, there were, in reality, only two. The bucket elevators mentioned at the bottom of Table II. were now obsolete, and the output of the turbo plants was not limited to the 70–80 tons per hour mentioned in Table III. The machines had actually handled up to 120 tons of grain per hour.

Before inviting Mr. C. R. S. Kirkpatrick, chief engineer to the Port of London Authority, to open the discussion, the President announced that a telegram had just been received from the Prince of Wales, thanking the Institution for the greetings sent to him in India on the preceding evening on the occasion of the annual dinner. The Prince is an honorary life member of the Institution.

Mr. Kirkpatrick said that the Port of London Authority possessed a number of conveyors which were fairly adaptable and could be employed in handling all sorts of cargoes, from frozen meat to tea. There was, however, one class of goods which still had to be man-handled, and that was timber. He noticed, in this connection, that Mr. Mitchell did not describe any apparatus for such a purpose. Timber arrived on the quay with all sorts of sizes and brands mixed together, and it appeared to him that the only way to get it sorted and put away in order was to take up each piece separately by hand. Mr. Kirkpatrick then went on to discuss pneumatic grain-handling plant, of which, he considered, the late Mr. Duckham was the pioneer. For this reason he had been all the more grieved to have to scrap some of Mr. Duckham's early machinery to provide room for the new electrically driven turbo elevators. The change, however, effected a great saving in space, as the old plant occupied 60,000 cubic feet and weighed 160 tons, while the new installation only required 22,000 cubic feet and weighed 50 tons. After Duckham, Mr. A. H. Mitchell might be considered as the second pioneer in this class of work, and in company with him the speaker had travelled all over Europe in 1912 to investigate the methods adopted abroad in handling grain, with the object of devising improvements in the plant at London. They heard that there was at that time a turbo elevator working in Russia, but they did not go to see it. In Hamburg they were told that turbo machines had been tried, but proved a failure. The German engineers predicted a similar fate for any turbo plant which might be put to work in England, but events had proved them wrong, as the new plant was quite a success. At Genoa there was a grain-handling installation which was the despair of its engineer. He had 1800 horse-power available, but was only able to deal with 450 tons of grain per hour. The reason for this enormous consumption of power was found to lie in a horizontal pipe, which reached 1500ft. along the jetty, through which the grain had to be drawn. The engineer said that it would cost £60,000 to remedy this drawback. In making comparisons between the elevators used in the Port of London and those of such ports as Antwerp and Rotterdam, it should be borne in mind that the conditions of working on the Continent were far more easy. There the barges had capacities up to 3500 tons; on the Thames the barges had to be small and their incessant manœuvring was a great check on rapid unloading. Mr. Kirkpatrick said that he was not yet quite certain whether reciprocating or turbo blowers were best for grain handling, and the Port of London Authority was leaving it to the discretion of manufacturers to tender for either type in new plant. He had a bias towards the turbo type of blower, but the speed-increasing gear used for driving it was a source of worry.

Mr. Scrutton pointed out that while the art of handling grain and similar cargoes had advanced enormously within the past twenty years, the handling of general cargoes was in much the same position as it was thirty years ago; in fact, there was actually a retrogression in one respect. The higher and broader vessels of these days entailed the fitting of longer jibs to cranes than were necessary a decade ago, with the natural result that the loads were handled more slowly. Conveyors suffered from the disadvantage that they could not be improvised, while the separate ownership of the ships, quay and warehouses also often militated against their use. He had, nevertheless, found that by arranging a conveyor to reach direct from the ship's hatches to a central point in the warehouse, a capacity three times greater than that of a crane alone could be maintained.

Brigadier-General Magnus Mowatt, the secretary of the Institution, who at one time was an engineer to the Port of London Authority, drew a comparison between bucket and suction elevators for handling grain, the choice between which, he said, depended largely on the conditions of the port. Thus on the West Coast of England, where grain cargoes were almost always delivered in bulk and were carefully graded before shipment, the bucket elevator was the most economical. The cargoes coming into London, on the other hand, could be dealt with best by suction elevators, as they were partitioned off by grass matting, while the grain itself was comparatively soft. There were, however, many other considerations which had to be taken into account, and as an instance General Mowatt mentioned a case in which the corn merchants complained that a cargo was being unloaded too quickly, as it was to their advantage to hold up supplies. Again, when the Dolphin elevators were first erected they were equipped with 1-ton Avery weighing machines, but they had to be taken out and small hand weighing machines substituted, as the merchants could not claim any allowance for inaccurate weighing with the better machines. He presumed, however, that the Port of London Authority was in a sufficiently strong position to override such opposition. In the early days of pneumatic grain handling the men were antagonistic to Mr. Duckham's plant, on the score that it would reduce employment, but now they were all in favour of the system. In this connection Mr. Mowatt suggested that it would be diplomatic to use the term labour-aiding rather than labour-saving, in describing such machinery. At Millwall there was once a transporter which picked up timber and took it from the water-side over a road to a field beyond, but it was not popular, as all the timber had to be sorted over again by hand.

Mr. H. J. Deane, chief assistant engineer, Port of London Authority, exhibited some characteristic curves which he had drawn to show the disabilities under which turbo exhausters work. The curves gave the relation between vacuum, volume and horse-power at different speeds for an ordinary turbo blower, and showed how rapidly the load on the motor and the volume of air delivered increased if the vacuum was spoiled by taking the suction nozzle out of the grain. What was wanted, he said, was either a machine which gave a constant vacuum or a device which would prevent the quantity of air delivered from exceeding a pre-determined limit. Another set of curves indicated the characteristics of a blower which met these requirements fairly closely. The overall efficiency of pneumatic grain-handling plants was, he said, obviously very low, as the machines described should, theoretically, be able to handle from 220 to 250 tons per hour, and actually handled only about 120 tons. It was not a good excuse to say that the gain in output, effected by improving the efficiency, would be useless as it could not be dealt with. If the efficiency were increased, the size of the plant could be reduced, and that would be a great advantage in a crowded port like London.

Mr. C. P. Kininmonth, of Messrs. Henry Simon, of Manchester, said that he had worked for some time with Mr. Mitchell, who had made distinct innovations in applying electric handling gear for the suction pipes and in installing oil engines for driving the blowers. At that time—about 1913—two-stroke oil engines were not nearly so reliable as they now are, and he thought that it required considerable courage to recommend their use. His firm had recently built a grain discharging tug, the Shannon, of which the beam was limited to 25ft., while a capacity of 200 tons per hour was required. The craft was, he said, quite seaworthy, and could go across the Atlantic fully rigged. It was not like the tall, unwieldy German machines, but could work under the yards of a square-rigged ship and yet reach 40ft. outboard. Mr. Patchell here remarked that the members would have been interested to have heard some particulars of the pneumatic coal-handling plant made by Messrs. Simons, but as the time was getting short, Mr. Kininmonth might perhaps give a description at the Manchester branch meeting. (A description of one of these plants appeared in THE ENGINEER of December 2nd.)

Mr. W. Reavell said that he thought the particulars given by Mr. Knight concerning the Dolphin elevators were rather misleading, as the demand was given as being 200 horse-power. That amount of power would be required if the machine were producing a vacuum of 15in., but only an 11in. vacuum was required for normal working, and could be obtained for an expenditure of 115 horse-power. One of the troubles which had to be overcome in connection with turbo blowers was to get a prime mover which ran fast enough. If an engine were used gearing would obviously have to be employed to increase the speed, and the same held good if the machine had to be worked off a direct-current electricity supply, as suitable motors could not be obtained in this country. A two-pole polyphase motor could, of course, be made to run sufficiently fast for direct coupling. Anyhow, satisfactory gearing could now be obtained for the purpose. In comparing the characteristics of turbo and reciprocating blowers, Mr. Reavell pointed out how the load on the latter was lightened if the suction nozzle were lifted out of the grain, while just the reverse happened with a turbo blower. His firm had, however, succeeded very largely in overcoming this difficulty, and the second set of curves which had just been shown by Mr. Deane was, in fact, taken from one of their machines. Mr. Reavell then explained, with the assistance of a lantern slide, how a speed regulation of 15 per cent. at the motor enabled the load to be kept nearly constant. The regulation was effected by utilising the drop in pressure across a diaphragm in the air pipe to actuate a rheostat. The same device could, he thought, be used to control a throttle valve in the air pipe, and thus reduce the overloading of plants driven by synchronous or other constant-speed motors.

Mr. W. H. Atherton, of the Ewart Chainbelt Company, Derby, showed a number of slides illustrating a very wide range of conveyors, and the two authors very briefly replied to the discussion.

ANNUAL DINNER.

The annual dinner of the Institution was held at the Connaught Rooms, Great Queen-street, on Thursday, December 15th, when the President, Captain Riall Sankey, took the chair. The attendance was very good, and there must have been over 400 people present, who included many distinguished guests; in fact, the reception room was so crowded that it was no easy matter to move about. In proposing the usual loyal toasts, the President announced that a telegram of greeting had just been sent, on behalf of the Institution, to the Prince of Wales. The toast of "The Houses of Parliament" was proposed by Dr. H. S. Hele-Shaw, who remarked that it was an old-established custom of the Institution to honour this toast, but that engineers did not, as a rule, dabble in politics. The Right Hon. Stanley Baldwin, President of the Board of Trade, responded in a speech, during which he criticised the non-technical Press rather severely, and pointed out that the country must have a Government of some kind or another, as it was the only safeguard between peace and anarchy. Mr. Richard W. Allen proposed "His Majesty's Forces," remarking that it would be a great blow to engineering if building operations for the Navy were entirely suspended, as the construction of warships contributed very largely to our fund of knowledge. In any case, he thought some warships should be built annually for experimental purposes. The remarks of Field-Marshal Sir William R. Robertson, who responded, naturally were chiefly concerned with the Army, which, he said, was run as economically as possible. If, however, we could not afford to keep the Army, we would have to change the national policy. In proposing "Kindred Societies," Mr. William Reavell urged that meetings between allied institutions should be held more often, while Mr. W. B. Worthington, President of the Institution of Civil Engineers, in acknowledging the toast, said that he thought that the various societies were now nearly pulling together. Electrical matters were the chief topic of Sir John Dewrance's remarks when he proposed "The Visitors," who were represented by Senatore Marconi, and he said that he actually saw the first electric light in England at the South Foreland. Senatore Marconi gave credit to mechanical engineering as being essential to the success of wireless work, and said that the world was evidently now too small for engineers, as we can telegraph as far as is possible on the globe, to the Antipodes. "The Institution of Mechanical Engineers" was proposed by the Right Hon. H. A. L. Fisher, President of the Board of Education, who recommended a closer collaboration between practical men and teachers, and asked for the preferential treatment, in commercial employment, for men of high distinction in technical instruction. In responding, Captain Riall Sankey referred to the proposal that certificates of registration should be made imperative for engineers, and pointed out that the memorandum of association of the Institution put it in a stronger position than would be the case if it had a Royal Charter.

* Our reprint follows the original text.—ED. THE E.

Developments in Power Station Design.

No. XX.*

Besides the new boiler plant described in our issue of Dec. 9th, other important additions are being made to the Neasden power station. The Metropolitan-Vickers Electrical Company is installing a new 12,000-kilowatt turbo-generating unit with a jet condensing plant, and capable of carrying an overload of 15,000 kilowatts. The original plant installed by this firm when the station was put into operation some seventeen years ago consisted of four sets rated at 3500 kilowatts. The turbines were of the double-flow reaction type, and had a full load steam consumption of 17 lb. per kilowatt-hour. Barometric condensing plant was also installed. In 1908 a new 5000-kilowatt machine was put into operation, whilst in 1910 one of the first four sets was re-designed and made to give the same output as the last-mentioned set. At that period, therefore, the station contained three 3500-kilowatt units, and two 5000-kilowatt units. In 1910, however, the Metropolitan-Vickers Electrical Company—then the Westinghouse Company—replaced the above reaction turbines by 5000-kilowatt impulse turbines, and the alternators belonging to the three original 3500-kilowatt units were re-wound. The barometric condensing plants were also replaced by condensers of the low-level Leblanc multiple jet type.

The new 12,000-kilowatt set which is now being erected, and which is shown in the drawing Fig. 94, is, of course, built in accordance with the makers' latest practice, and as the following table indicates, it is capable of a much better performance than that of the machines which were built earlier.

	Existing sets.	New sets.
Normal output, in kilowatts	5000	12,000
Speed, revolutions per minute	1000	2,000
Phase/Periodicity/Volts	3/33⅓/11,000	
Steam pressure at stop valve, lb. per square inch (gauge)	175	250
Total steam temperature, deg. Fah.	540	650
Vacuum (barometer 30in.), inches	28	28.15
Steam consumption in lb. per kilowatt-hour—		
Full load	14.0	10.8
Three-quarter load	14.3	10.82
Half load	15.0	11.5
Alternator efficiency—		
Full load	95.5	95.25
Three-quarter load	94.5	94.75
Half load	92.5	92.0
Temperature of circulating water, deg. Fah.	82	75
Quantity of circulating water, gallons per minute	9000	11,600
Speed of condenser pumps, revolutions per minute	380	480
Capacity of auxiliary turbine, in brake horse-power	460	530
Speed of auxiliary turbine, in revolutions per minute	3000	4500
Steam consumption of auxiliary turbine, in lb. per brake horse-power-hour	28.3	20.5

* No. XIX. appeared December 9th.

Although the steam consumption given in the above table is good, owing to the provision of an external feed-water heater with a heating surface of 700 square feet, there will, it is said, be a considerable saving in coal over and above that represented by the improvement in the steam consumption indicated. The turbine is a Rateau machine, and, as shown in the table, it drives the alternator at a speed of 2000 revolutions per minute when working with steam at a pressure of 250 lb. per square inch and superheated to 650 deg. Fah. The alternator is designed to generate three-phase current at a periodicity of 33⅓ cycles per second and at a pressure of 11,000 volts. At a power factor of 0.95 the normal capacity of the alternator is 12,630 k.V.A., which corresponds to about 16,100 horse-power. For cooling purposes 45,000 cubic feet of air are delivered to the machine per minute. The alternator is totally enclosed, and the cooling air is cooled at the rate indicated by means of a special cooler erected in the foundations, as shown in the drawing. The weight of the complete set is about 140 tons. The low-level multi-jet condenser already referred to is situated immediately below the turbine, and will maintain a vacuum of about 28.1in. with the barometer at 30in., when dealing with 131,000 lb. of steam per hour and when supplied with cooling water at a temperature of 75 deg. Fah. The duplicate air and extraction pumps used in connection with the condensing plant are mounted on a common shaft directly connected at one end to a 590 horse-power slip-ring induction motor, and at the other end to an auxiliary turbine.

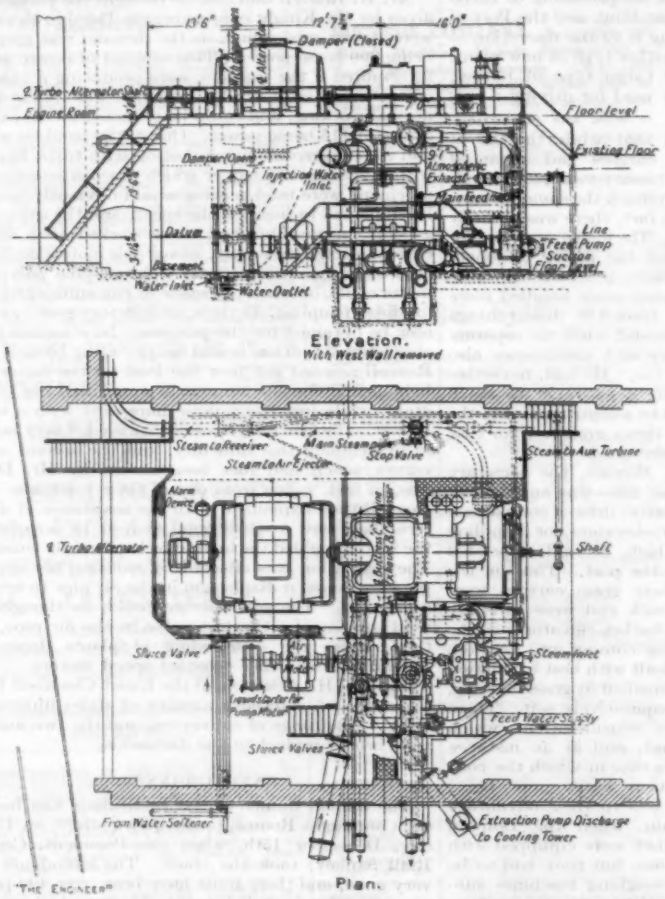
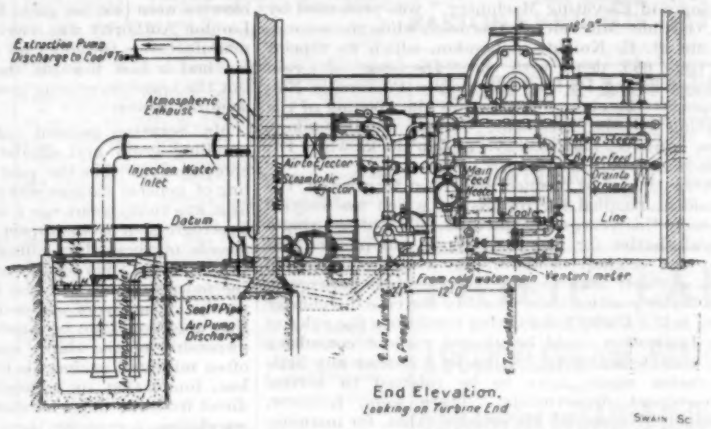


FIG. 94—ARRANGEMENT OF 12,000-K.W. GENERATING SET AT NEASDEN



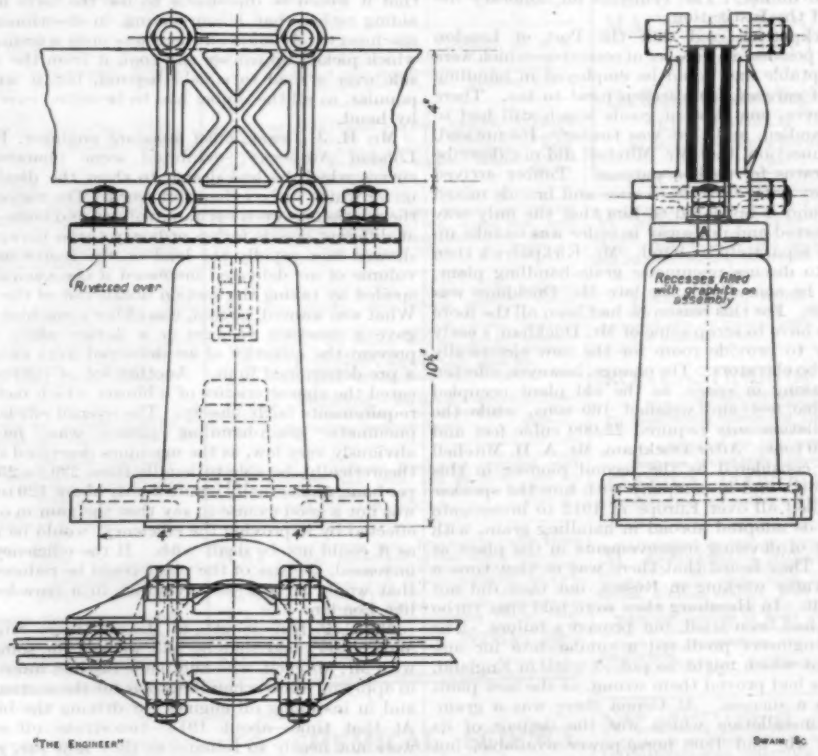


FIG. 95—BUS-BAR CLAMP

For measuring the water supplied to the boilers the Lea Recorder Company, of Deansgate, Manchester, is installing two of its well-known recording and integrating machines, which give the total quantity of water passed, the rate of flow in pounds per hour, which is shown on an indicating drum, and also a permanent record of the rate of flow and the total quantity of water. As jet condensers are used in this station the water from the cooling tower bus-pipe is led into each Lea notched measuring tank, the supply being governed by means of an 8in. equilibrium valve in accordance with the demands of the feed pump. The chamber containing the float for operating the instrument is placed in the basement of the turbine room, and is connected to the measuring tank by means of an equalising pipe, and a connection is taken from this float in the float chamber to the instrument, which is mounted on an iron table on the turbine room floor. For pumping the water from the company's three artesian wells, Alley and McLellan are supplying two "Sentinel" motor-driven air compressor sets, each having a capacity of 490 cubic feet of air per minute and running at 320 revolutions per minute. These sets are to replace two obsolete steam-driven pumps.

The switchgear associated with the Neasden extensions is being supplied by the General Electric

Company, of Witton, Birmingham. The main control gear is designed for a pressure of 11,000 volts, and it is to control one 12,000-kilowatt generator and five 5000-kilowatt generators, working at a periodicity of 33⅓ cycles. Switchgear made by the same firm is also being supplied for the control of fifteen outgoing 300-ampère feeders supplying the sub-stations at Baker-street, Moorgate-street, Harrow, Ruislip, Drayton Park, Bouverie-street, Gloucester-road, Finchley-road and Neasden, two outgoing feeders to two 1500-kilovolt ampère station transformers, and one works feeder connected to a 350-kilovolt ampère transformer. The gear is to be erected in a special switchgear house adjacent to the main power station, "Pirelli General" cables being run in separate stoneware duct laid in concrete and passing between the cooling towers. This building, the chief engineer of the Metropolitan Railway informs us, is being erected on account of lack of space in the power-house itself, and will have three storeys. The practice of separating the switchgear from the main building of large power stations is, of course, recognised to be a good one, but in this particular instance the adoption of the scheme appears to be due mainly to the lack of accommodation in the power-house. The bus-bar chambers—see Fig. 96—will be on the top floor of the building, the oil switches on the middle floor, and the potential transformers, which are to be of the oil-immersed type, will be placed in the basement, together with the cable boxes and feeder isolating links. The cells will be composed of brickwork with horizontal partitions composed of artificial stone. The switches are to be operated on the electric remote control system, and their respective operating panels will be in a separate control room on the top floor. An engine-room marine type telegraph system now in the course of construction at the General Electric Company's works at Wembley, is to be provided for communicating between the switch control room and the turbine room. Automatic field switches will be fitted adjacent to each alternator. Besides the above equipment, the General Electric Company is supplying six earthing panels for the turbo-alternators, sixteen boiler-plate cubicles for the low-tension sides of the transformers and distributing feeders for the auxiliary plant; also the cables for the generators, feeders, &c., and McColls' patented protective gear for the generators and transformers. The walls of the cubicles are to be 4½in. thick, whilst the steel plate doors will be $^3/_{16}$in. thick, and are to be fitted with strong malleable iron hinges designed to withstand heavy internal pressure. The doors are also to be fitted with stout padlocks.

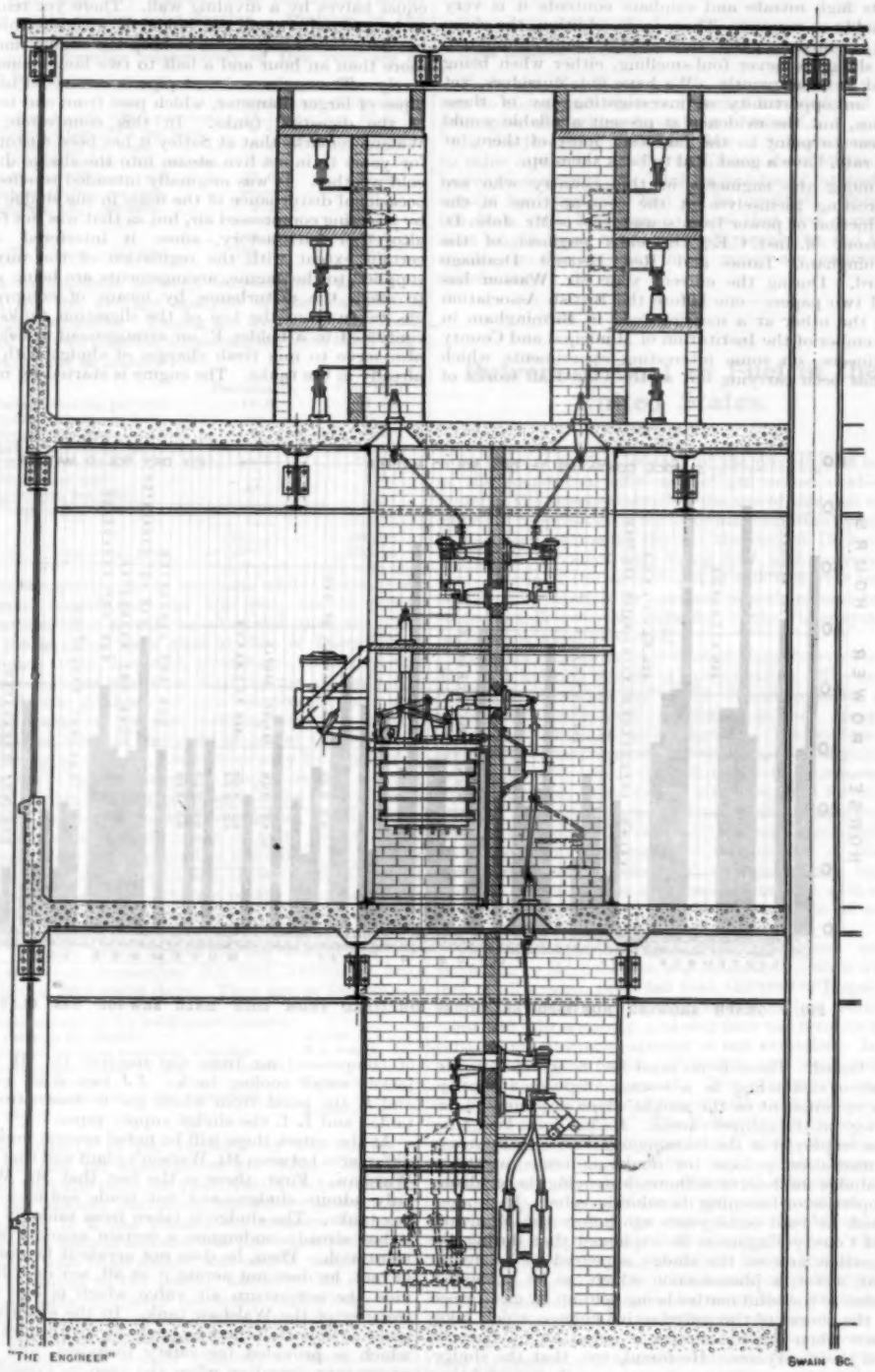


FIG. 96—HIGH-TENSION SWITCHGEAR

In order to isolate the gear to the greatest possible extent, each cubicle is to be divided into compartments.

The switches which are now under construction has been designed to deal with short circuits giving rise to an instantaneous output of 600,000-kilovolt ampères, and to possess a sufficient factor of safety as regards breaking capacity, to deal with the short circuit current, if this happens to coincide with the instant of rupture. All switches made at the Witton works are subjected to a very thorough pressure test. The standard test pressure is at least 2000 volts, plus two and a-quarter times the voltage between phases, whilst the insulators are tested individually at a pressure of at least three times the working voltage. The total length of the double break is 12in., and each phase of the switch is broken in 22 gallons of oil. The closing solenoid is mounted on a strong steel framework, which forms the front of the three-cubicle structure, the main framework of the cubicle being composed of stout channel and angle iron, whilst brickwork or concrete partitions entirely divide the phases.

In the past many accidents have occurred as the result of tanks being blown open under short circuit conditions, but it is claimed that with the exceptionally strong channel and angle iron reinforcements which are fitted to the General Electric Company's welded tanks, which are lined with five-ply birch, accidents of this sort are impossible. Each tank fits into a deep recess, and a thick gasket at the top prevents the emission of fumes. On all the switches the movable contacts are wedge-shaped, whilst the fixed contacts are of the controller finger pattern. Substantial sparking contacts are also fitted, and they are sufficiently long to enable a high-speed break to be obtained before rupture, the speed of each break being 6ft. per second, or an actual speed for the two breaks of 12ft. per second. To avoid damage to the switches, air dashpots are fitted so that the heavy moving parts can be brought to rest without shock to the mechanism. The feeder switches are fitted with overload and leakage release gear with a time element, and the generator switches are provided with reverse-current relays. McColl biassed relays are provided for the transformer circuits. Current-limiting resistances are provided in all the potential transformers for limiting the short-circuit current, which may have to be dealt with by the fuses in the event of a breakdown of these potential transformers.

The bus-bars, which are composed of high-conductivity tinned laminations firmly bolted together, are mounted on porcelain insulators, capable of withstanding the mechanical stresses set up by heavy short circuits, and in order to allow the bars to expand freely, special bus-bar clamps are employed, as shown in Fig. 95, where it will be seen that owing to the bolt holes A being slotted and the provision of a recess for the reception of graphite, the bars are free to expand longitudinally. Each bar is placed in a separate compartment, which is fitted with a steel door, which can be removed to enable the bars to be inspected. The leads belonging to the various phases are run in separate compartments, and those from the oil switch chambers are placed in Bakelite ducts. Special precautions have been taken to prevent any gas which may be generated to the oil switch chambers from entering other compartments and special fume-tight insulators are used for leading in the connections. Each switch is connected to a ventilating duct, which enables the gases to pass into the atmosphere outside the generating station. The operating board from which the switches are controlled on the electric remote control system is of the flat-back type, and on this board the controllers, instruments, &c., are mounted.

Power from Sewage Gas.

No. II.*

THE Walshaw method of obtaining gas from sewage and utilising it for power purposes has been employed successfully in several places in Australia, among which may be mentioned Parramatta, Brisbane and Lithgow. At the first-named place, the sewage, which is that produced by 13,000 persons, gravitates to a pumping station, whence it has to be raised to the treatment tanks, a distance of some 3000ft., against a head of about 30ft. Up till the year 1914 the pumping was done by a steam plant, which was in operation for sixteen hours out of the twenty-four, and which cost about £800 per annum for fuel alone. In that year, however, Mr. Walshaw obtained the sanction of the Municipal Council to adapt his invention to the installation, and he proceeded to lay down a 17 brake horse-power Hornsby gas engine at the pumping station. From that time till the present, no other fuel than the gas obtained from sewage has been employed, and the total annual saving is said to exceed £1000. The engine, according to information which has been supplied to us, runs continuously for twenty-four hours in the day and receives practically no attention, "only the necessary oiling and cleaning being required." Prior to the system being put to work there were apparently numerous complaints from the inhabitants of the surrounding neighbourhood, but since the gas plant has been in operation the smells have been entirely eliminated.

The analysis of the gas, as the result of taking the average of fifteen samples procured at different dates is given by Messrs. Julius and Poole, consulting engineers, of Sydney, who were called in to investigate the process, as being as follows:—

	Per cent.
Carbon dioxide (CO_2)	14.0
Oxygen (O)	1.1
Methane (CH_4)	60.0
Hydrogen (H)	8.0
Nitrogen (N)	16.9

The different analyses only varied, we are told, within narrow limits, while the caloritic value was practically constant at 600 B.Th.U. per cubic foot.

Messrs. Julius and Poole in their report on the subject state that the average consumption of the

* No. I. appeared December 16th.

gas per brake horse-power hour in a well-designed engine would be approximately 14, so that assuming a production of 3 cubic feet of gas per twenty-four hours per head of the population, the amount of gas produced at Parramatta—13,000 × 3 = 39,000 cubic feet per day—would on the basis of 14 cubic feet per horse-power hour, be sufficient for the development of 115 horse-power continuously, or practically 9 brake horse-power continuously per 1000 inhabitants.

At Parramatta, we understand, the atmospheric temperature is sufficiently high to obviate the necessity of using any of the gas to heat the sewage in the tank, but it is clear that, in colder climates, if a temperature of 70 deg. is to be maintained, as suggested by Mr. Walshaw, a not inconsiderable amount of gas, if used in a separate apparatus to heat water or to produce steam, would be required. Such consumption would, of course, reduce the volume of gas available for aerating and other purposes. As we shall see, however, the exhaust gases from the engine are in one case, at any rate, being employed for heating purposes; but then, of course, it would appear that the engine must run continuously if the temperature is not to be allowed to fall. In the case of Parramatta there should be a very considerable amount of power available over and above that required for pumping. Taking the population at 13,000 and the gallons of sewage per head per day as 25, that would mean 325,000 gallons per day. The height through which it has to be lifted is 30ft., so that the work to be done is, say, $325{,}000 \times 10 \times 30 = 97{,}500{,}000$ ft. lb. or $\frac{97{,}500{,}000}{33{,}000 \times 24 \times 60}$ = just over 2.0 horse-power with the engine working continuously, leaving out the question of efficiency.

At the moment it is not quite clear how much gas is actually being obtained at Parramatta. It is probably quite safe to count upon 3 cubic feet per head of population per day under average conditions, which is the figure assumed by Messrs. Julius and Poole in their calculations, but the quantity must obviously vary with different conditions. As much as 4 cubic feet per person per day has been found in some instances, and it is claimed for the Walshaw method that by it more gas is obtained from a given volume of sewage than by means of any other method of treatment. It is furthermore claimed that by it a community can, without cost for fuel, develop sufficient motive power to supply its street lighting and to meet all ordinary consumers' needs. The gas, it may be added, can be stored under pressure in gasometers or other receptacles, which must, of course, be entirely separate from the treatment tank.

Considerable stress is laid on the fact that the gas is singularly free from sulphuretted hydrogen, which has a deleterious effect when burnt in engines. The gas is described as being colourless, odourless, smokeless, dustless and dry, and it is said that there is practically no deposit whatever in the engine cylinders. On this point we can quote from the report of an independent expert, who was called in to make investigations after the plant had been at work for a lengthened period. His remarks are as follows:—"I must say that for the time the engine has been running it is in perfect condition, with the exception of slight erosion on the stem of the exhaust valve which would be caused by moisture in the gas. At the present time the cylinder walls, piston and ignition points are in very good order." Another report states that the engine at Parramatta, after working for nine months, "was found to be almost as clean as when first started; there was not as much carbon as would blacken the top of a match box." We gather that not only is the engine still at work, but that another engine of like power was put in some time back and is operating side by side with it.

Before turning from what has been done in Australia to discuss what is being done in this country in the way of producing power from sewage gas, we may usefully refer to the question of the sludge which remains in tanks of the Walshaw type. There are several assertions made concerning it. There is, first of all, the statement that because the sludge is digested in an aerated state, not only is a greater volume of gas given off than would otherwise be the case, but the bulk of the sludge is greatly reduced. Then, again, it is said that the sludge when dried is of a more earthy or loamy nature than is the sludge produced by any other method; that the solids separate from the liquid more readily, and hence that the sludge is more easily dried; and that on account of its high nitrate and sulphate contents it is very valuable as manure. There is, in addition, the claim that the noxious gases, such as H_2S, being eliminated, the sludge is never foul-smelling, either when being dried or subsequently. We have not, ourselves, yet had an opportunity of investigating any of these claims, but the evidence at present available would appear to point to the fact that most of them, at any rate, have a good deal to back them up.

Among the engineers in this country who are interesting themselves at the present time in the production of power from sewage gas is Mr. John D. Watson, M. Inst. C.E., the chief engineer of the Birmingham, Tame and Rea District Drainage Board. During the current year Mr. Watson has read two papers—one before the British Association and the other at a meeting held in Birmingham in November of the Institution of Municipal and County Engineers—on some interesting experiments which he has been carrying out at the Cole Hall works of his Board. There is no need for us to refer to Mr. Watson's standing as a sewage disposal authority, nor to comment on the weight which anything he has to say on the subject carries. He has for a long time now employed at the Birmingham works an intensive fermentation process for rendering large quantities of sludge inoffensive without destroying its fertilising properties or lessening its calorific value. In a paper which he read some years ago before the Municipal and County Engineers he explained that during the digestion process the sludge appeared to be lighter than water, a phenomenon which, as he explained, is due to the solid matter being held up by gas formed in the course of the putrefactive change which takes place when organic matter is acted on by bacteria and their enzymes. He found, too, that the sludge, when in that condition, was more easily pumped than when it was fresh, and that the friction experienced in the process of forcing it through a cast iron main, 5 miles in length, was lessened. He assumed that the comparatively frictionless propulsion of the solids through the main was probably due to reduced density in the sludge, and to an innumerable number of gas bubbles acting like so many ball bearings between the solids, thus tending to reduce the viscosity of the whole.

In 1920 Mr. Watson happened to visit the Mutunga Leper Asylum, where, as mentioned in the previous article, Mr. James had carried out his experiment in driving a gas engine. Not long afterwards his attention was drawn to the results which had been achieved in Australia with the Walshaw tanks, and it was the conjunction of the two which induced him—to quote from one of his papers—"to try where it was possible to obtain equally successful results in this changeable unreliable climate of ours."

It so happened that the Drainage Board had some years previously approved plans for driving a pump at the Cole Hall station by means of a suction gas plant. On his advice, the Board consented to the scheme being varied to admit of an attempt being made to drive the engine by means of sewage gas. Very little alteration was necessary and but little expense was incurred in defraying the cost of the experiment.

The plant which he has installed is designed to give 25 brake horse-power for a working period of six hours per day. Its arrangement is shown diagrammatically in Fig. 4. The engine A which was made by the National Gas Engine Company, Limited, is of 34 horse-power maximum, and it drives by belt a 5in. centrifugal sludge pump B made by the Unchokeable Pump Company, which is intended to pump the sludge from the sludge well C. There is a sludge digestion tank D, which is divided into two equal halves by a dividing wall. There yet remains to be erected a small gas holder E without which it has been found impossible to keep the engine running more than an hour and a-half to two hours consecutively. The engine exhaust pipe is connected to two pipes of larger diameter, which pass from end to end of the digestion tanks. In this connection, Mr. Watson remarks that at Satley it has been customary for years to inject live steam into the sludge during cold weather. It was originally intended to effect an occasional disturbance of the mass in the sludge tank by injecting compressed air, but as that was not found altogether satisfactory, since it interfered to a certain extent with the regulation of the mixture supplied to the engine, arrangements are being made to effect the disturbance by means of compressed gas taken from the top of the digestion tanks and contained in a holder F, an arrangement which will also serve to mix fresh charges of sludge with that already in the tanks. The engine is started by means of compressed air from the receiver G. H is the jacket water cooling tank; J J two relief valves; and K the point from which gas is drawn from the tanks, and L L the sludge supply pipes.

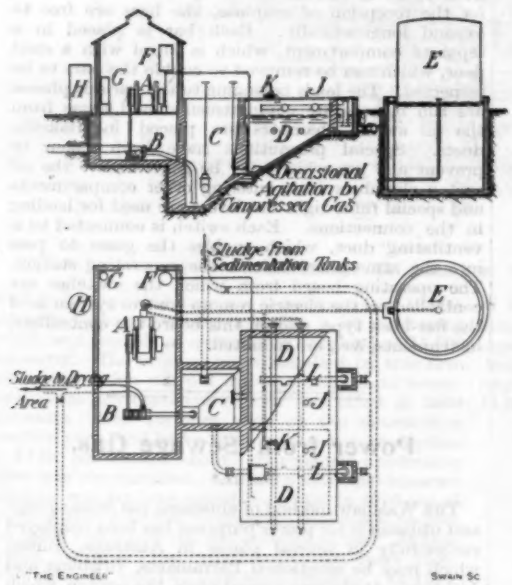


FIG. 4—THE WATSON SEWAGE GAS PLANT

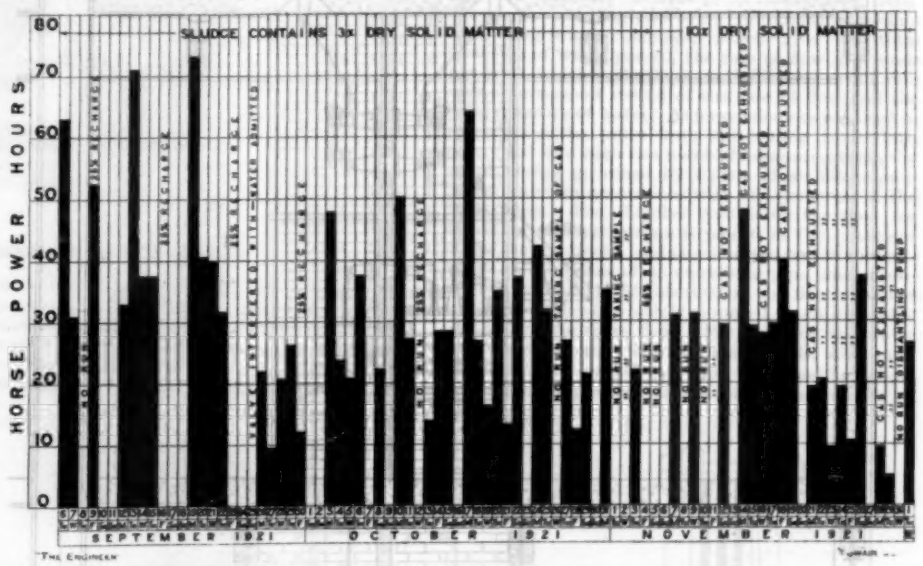


FIG. 5—GRAPH SHOWING HORSE-POWER HOURS OBTAINED FROM COLE HALL SEWAGE GAS PLANT

At the outset there will be noted several important differences between Mr. Watson's plant and that of Mr. Walshaw. First, there is the fact that Mr. Watson only admits sludge—and not crude sewage—to his gas tanks. The sludge is taken from tanks in which it has already undergone a certain amount of sedimentation. Then, he does not aerate it beforehand; in fact, he does not aerate it at all, nor does he provide the non-return air valve which is one of the features of the Walshaw tank. In the experimental plant at Cole Hall there is, however, an air inlet valve, which is provided for safety purposes, and which comes into operation when the vacuum exceeds that due to 24in. of water. When the gas holder is provided and weighted to give a slight "pull" on the tank, Mr. Watson thinks there will be less necessity for this valve than there is at present, and, in his opinion, there is no need for the suction fan which is shown in the Walshaw tank illustrated in Fig. 3 in out last issue. Yet again the Cole Hall tanks are not divided vertically in the same way as are the Walshaw tanks. Each half of the Watson tank is a plain rectangular tank with no subdividing septum. Finally, there is no equivalent in the Walshaw plant for periodical agitation of the sludge, as is provided in the Cole Hall plant.

Mr. Watson has courteously given us his reasons for the various dissimilarities which exist between the two plants. The Australian plant seems, he remarks, to aim at the purification of the sewage and the generation of gas in one and the same tank. In his view, that is not practicable. He is convinced that the gas comes from the solids in the sewage, but in

saying that he does not wish to exclude the particles of solid matter found in the liquid. The aerating operation advocated by Mr. Walshaw has, Mr. Watson thinks, less to do with the generation of gas than with the effort to keep the supernatant water in the tank free from putrefaction. In saying this, he is, he remarks, conscious that sewage is so complex in its character, and varies so much in different places, that apparent contradictions are sure to manifest themselves from time to time, but it will, he adds, be found almost invariably that that view is correct. He regards the Cole Hall experiment purely as an attempt to obtan power from sewage sludge in a practicable manner; the experiment is, he says, still immature, though it is in a distinctly hopeful state.

Up till comparatively recently, for reasons into which we need not enter, the sludge available at Cole Hall was very watery, only containing about 3 per cent of dry solid matter Analyses of the gases obtained with sludge of that strength in September and November respectively of this year are as given below :—

	September.	November.
Carbon dioxide (CO_2), per cent.	18.1	25.2
Hydro-carbon (HC), per cent.	0.2	—
Oxygen (O_2), per cent.	0.4	0.3
Carbon monoxide (CO), per cent.	1.1	—
Methane (CH_4), per cent.	77.0	67.5
Ethane (C_2H_6), per cent.	trace	2.8
Nitrogen (N_2), per cent.	3.2	4.2
	100.0	100.0
B.Th.U.'s per cubic foot	700.0	650.0

The comparison between these figures and those given for the average analysis of the Parramatta gases is instructive Taking the average of the readings of the two months, they compare with the Parramatta figures as follows :—

	Parramatta.	Cole Hall.
Carbon dioxide, per cent.	14.0	21.65
Hydro-carbon, per cent.	—	0.1
Oxygen, per cent.	1.1	0.35
Carbon monoxide, per cent.	—	0.55
Methane, per cent.	60.0	72.25
Ethane, per cent.	—	1.4
Hydrogen, per cent.	8.0	—
Nitrogen, per cent.	16.9	3.7
	100.0	100.00
B.Th.U.'s per cubic foot	600.0	675.00

It is the marsh gas or methane which is the most important constituent for the purposes of power production, and it will be observed that the Cole Hall gas is richer in it than is that of Parramatta. Too much stress, however, should not be laid on the divergence, since the Cole Hall figures are only the result of the analyses of two samples of gas, and greater variation in the methane contents might well be met with in the yield of gas at those works. Still, as far as they go, the figures may be considered to be very good, especially having regard to the watery nature of the sludge and to the time of year in which the second sample was taken. The month of November was cold, but it is quite evident that sufficient heat was imparted to the sludge by passing the exhaust from the engine through pipes in the tank to maintain the activity of the bacteria. The Cole Hall gas, it will be noted, is of particularly high calorific value.

Mr. Watson gives figures of the working of the plant between September 6th and November 3rd, a period of fifty-eight days. They are as follows :—

Total amount of dry solid matter passed through the tanks	4 tons
Average period of retention of sludge	6.4 weeks
Average percentage of dry solid matter in wet sludge	3 per cent.
Estimated amount of gas consumed by engine	25,000 cu. ft.

The quantity of gas required by the engine is 20 cubic feet per horse-power per hour. It is explained that the total gas yield was, of course, greater than the amount indicated, but under present circumstances it is not possible to measure the yield exactly. A certain amount was lost when recharging the tanks with fresh sludge, and also in making tests and alterations to the plant. Latterly, Mr. Watson has been able to charge his tanks with sludge containing 10 per cent. of dry solid matter, and, judging from the limited experience which he has, as yet, had, he estimates that a daily quantity of about 2 tons of such sludge will be required to provide an explosive gas capable of generating 25 brake horse-power for a working period of six hours per day, or 150 horse-power hours. At the Cole Hall works alone the amount of sludge containing 10 per cent. of dry solid matter which is available per day is given as being 80 tons, so that on the basis of Mr. Watson's calculation of 2 tons of the sludge producing 150 horse-power hours, the total daily power which should be available at that disposal works alone is forty times that amount, that is to say, 6000 horse-power hours, or 1000 horse-power for a working period of six hours per day. We may here draw attention to Fig. 5, which shows a graph kindly furnished to us by Mr. Watson, in which the output of gas from the Cole Hall tank over a lengthy period is set out.

On the important question of whether or not it would pay to go to the necessary outlay to use the large quantity of gas, which under suitable conditions can be obtained from sewage, Mr. Watson gives the following figures, although, as he says, there has hardly been sufficient experience as yet to obtain really reliable data.

Duty, 25 B.H.P. for a Daily Period of Six Hours.

The cost of gas engine, engine-house, pump and pump well, being common to both plants, is ignored in the comparison. The cost of labour, lubrication and repairs is also approximately equal, and does not appear in the comparison.

	£ s. d.	£ s. d.
Suction gas plant—		
Capital cost of suction gas plant of similar capacity, £300; annual charge on £300 at 10 per cent.	30 0 0	
30½ tons of anthracite at £3 per ton, allowing 1¼ lb. per B.H.P. hour	91 10 0	
		121 10 0
Sewage gas plant—		
Cost of constructing generating tanks, with complete equipment of fittings and all pipe work, £600 at 7 per cent., repayable in twenty-five years	42 0 0	
Provision for gas holder, £500 at 10 per cent., repayable in fourteen years	50 0 0	
		92 0 0
Net annual saving in favour of sewage gas plant		£29 10 0

Probably, Mr. Watson adds, the sewage gas plant can be cheapened when more exact knowledge of the principles of working have been obtained.

In the foregoing articles it has only been possible to refer in outline to the two methods of obtaining power from sewage gas. Quite a number of interesting details has, perforce, had to be omitted. Enough has been said, however, to show that this question is at length being taken up really seriously, and that results, so far as they have gone, are eminently satisfactory.

Pulverised Coal as Fuel in the United States.

No. II.*

In spite of the inadequacy of the records and tests of the economical efficiency of pulverised coal—as noted in the previous article—the use of this fuel continues to progress, even for large and important plants. It has been estimated that at the end of 1919 over one hundred boilers were being fired with pulverised coal. Some of the advantages of this fuel over lump coal fired by hand or by mechanical stokers have been stated as follows by Mr. Scheffler, of the Fuller system for burning pulverised coal.

Troubles caused by poor coal are largely overcome. The coal burning system is more flexible. The combustion is smokeless and rapid. Stand-by losses are practically eliminated. Firing can be stopped instantly. There is no clinkering. The system is applicable to any operations where heat is required, except those in which the ash might be detrimental to the material. Less excess air is required for combustion. Troubles arising from high temperature can be controlled. Practically all the combustible constituents in the coal are consumed. A plant equipped to burn pulverised coal is largely independent of coal dealers and the coal market, as it can operate successfully on the cheapest grade of coal obtainable in the vicinity.

The efficiency obtained with pulverised coal, according to Mr. Scheffler, is practically the same with fuel of all grades, provided that the coal is prepared properly. Only coals having an ash of low melting point will slag seriously, and slag does not form on the tubes if the furnace capacity is not exceeded. In a properly designed furnace all carbon and combustible material will be consumed. For starting a small wood fire can be used until the fire-brick is hot enough to support combustion. The Fuller Company has had no explosions in the furnaces, and where flare-backs have occurred they were the result of ignorance or carelessness. Nor is there danger of explosion in a plant properly installed and properly managed. If the pulverised coal in the storage bins should become ignited the only result will be a coking action, which may necessitate ceasing to deliver fuel to the bin.

As far as the size of the plant is concerned, it appears that in general any plant using more than 100 tons of coal daily could show a sufficient saving in cost of operation to warrant the provision of a pulverised coal equipment. If space be limited, the drying and pulverising apparatus can be placed conveniently in the upper floors of the power station. A boiler with a combustion chamber properly designed, operated twenty-four hours a day and burning 1200 lb. per hour of inferior bituminous coal containing 10 per cent. ash, should not need cleaning more than once in eight hours. From 30 to 50 per cent. of the ash passes out of the chimney as dust, most of this being so fine that it is carried away and does not form a nuisance, but most of this dust can be removed by collectors if it is objectionable. Boilers with tubes placed vertically or nearly vertically are found to require no more blowing out than if fired by hand or by mechanical stokers. Although more frequent blowing is required in other types of boilers, this work is simplified by the use of the soot blowers now in general use.

The advisability of adopting pulverised coal for generating steam at any particular point will be determined largely by the cost of the plant required for drying and pulverising. The extra investment thus entailed for the burning of pulverised coal has become a materially less serious obstacle because the excessive price of coal has encouraged thorough investigation of any process which appears to promise greater efficiency and economy. These were the considerations which led the Milwaukee Company to begin the installation nearly three years ago of pulverised coal furnaces at its then existing plant, described in the former article.

In a paper reviewing the features of this system, Mr. John Anderson, chief engineer of the Milwaukee Company, stated that it was necessary to pass the coal over a magnetic separator to remove bolts, spikes, nuts, pick points, and other specimens of "tramp" iron which might cause serious damage to the crushing and pulverising machinery. Unless coal was delivered in sizes smaller than ¾in. screenings a crusher had to be employed to reduce the raw coal to a size suitable for drying and pulverising. Drying was necessary to obtain the most uniform temperature conditions in combustion, for moisture checked the regularity of the flow of mixed fuel and air to the burners. A rotary drier was used as a rule and reduced the moisture content to 1 or 2 per cent. In the pulverisers the coal was reduced to such a degree of fineness that 80 to 85 per cent. would pass a 200-mesh screen. An auxiliary equipment for collecting and recovering the dust was of great importance in securing the cleanest and most economical operation.

The cost of preparing the coal varies with the size of the plant and the quantity of fuel handled, but ordinarily it will be between 25 and 50 cents per ton—say, 1s. to 2s. There is a wide field for reducing this cost, especially in the way of utilising the waste gases for drying, in plants not equipped with economisers. Another line of study suggested is the development of a furnace design which will permit of burning a large percentage of finely divided coal or a smaller amount of coarser material, the economy of this procedure lying in the fact that the pulverising machinery consumes some 86 per cent. of the total electric energy required for operating the machinery incidental to the preparation of the fuel.

Continuous and uniform operation of the pulverising department is dependent largely upon the ability of the attendants to recognise and meet the varying properties of the coal supplied. The drying particularly must be changed promptly to deal with coal varying from a high percentage of fine to a high percentage of small nuts and with varying amounts of moisture, and still to deliver continuously a coal of uniformly low moisture content. Irregularities in the drying process are likely to affect the entire coal cycle, and often have the result that the fuel feeding apparatus becomes clogged at points most readily affected by wet coal.

Air taken through auxiliary inlets in the furnace front supplements that which carries the fuel, and this supplementary supply can be regulated by the damper in the chimney, this damper serving to control the gas velocities through the boiler and therefore the volume of air drawn into the furnace. With coal and supplies easily adjustable perfect control of the fire is assured, and this fact is the reason why coal can be burned so efficiently in pulverised form. Further, with fuel finely pulverised, air can be made available at once to each particle, so that combustion is rapid, complete and efficient as compared with coal in lump form.

A furnace burning pulverised coal can use widely varying grades of coal without a corresponding variation in economy, and even under heavy overloads the boiler capacity is not affected by a change to an inferior quality of coal. Thus the combined efficiency of boiler and furnace does not decrease when the fuel is poor. With a stoker-fired furnace, however, the drop in efficiency is at a more rapid rate than the calorific value of the coal would indicate as normal, and in fact a point is rapidly reached at which proper combustion cannot be maintained. The operation of the pulverised coal-fired boiler, equipped with proper instruments, can be varied to take big fluctuations of load over very brief periods. Thus a heavy overload can be taken on or dropped off quickly by the adjustment of the air and fuel feeds and without the loss of fuel which attends similar conditions with a stoker-fired boiler. Losses caused by clinkering, cleaning fires and adjustments to variations in quality and size of coal are eliminated, while furnace conditions necessary to highly economical combustion are obtained readily.

With regard to maintenance features, Mr. Anderson with an experience of over two years, is of opinion that the brickwork in a pulverised coal furnace will give as good service as that in a stoker-fired furnace, while the former has the advantage of eliminating all iron-work in the furnace or near the high-temperature zones. Experience indicates that no large amount of maintenance of the pulverising plant is likely to be necessary, but at the same time there are opportunities for improvement in the reduction of the liability to trouble as well as in the increase of the maintenance economy. One limitation upon pulverised fuel installations is the size of boiler plant to be served. The adoption of the system is not considered advisable for a plant of less than 2500 brake horse-power on a

* No. I. appeared December 16th.

twenty-four-hour operating basis. The reasons for this limitation include the cost of machinery and its operation as compared with the amount of coal to be pulverised daily.

Referring once more to the Milwaukee plant, Mr. Anderson has stated that on the whole the application of the pulverised coal system to the existing boilers has been distinctly advantageous, while its economy has been proved by the coal bills. The firemen prefer to operate this equipment rather than the automatic stokers. It forms less scale and there is no trouble from smoke or from soot on the tubes. In ordinary furnaces high sulphur coal causes a destructive action on the tubes, and all steel equipment, but this trouble is slight in pulverised fuel furnaces because of the low moisture content of the coal as fired. Freedom from explosions is attributed mainly to careful handling and to the pains taken to see that the coal is not pulverised to a fineness beyond what is necessary or dried to an excessive degree.

Another case of the application of the pulverised coal system to an existing boiler plant is that of the Puget Sound Traction, Light and Power Company, at Seattle, on the Pacific Coast. A waste bank of culm from a local lignite coal contains some 225,000 tons, and investigation showed that it would be economical to utilise this material and to abandon oil fuel, the cost of which has increased considerably. The culm has a fuel value of 7300 B.Th.U., with 25 per cent. moisture content, 28 per cent. volatile matter, 26 per cent. fixed carbon, and 20 per cent. ash. Its cost is only about 7s. 6d. per ton delivered into the raw coal bunkers. The material is loaded into the tramway company's cars at the mine and delivered at night to storage bunkers of 750 tons total capacity. After passing through a crusher it is conveyed to a 350-ton concrete bin.

From the bin the crushed coal is fed through 10in. pipes which have motor-driven paddles to ensure a uniform and continuous flow. These pipes supply two indirect-fired rotary driers of 7 and 10 tons capacity per hour, furnished with induced draught by turbine-driven fans which discharge into the heads of cyclone separators. They require about 1 ton of pulverised coal fuel to dry 20 tons of raw coal. The dried coal passes through a magnetic separator for the removal of iron and is then carried by 12in. screw conveyors to a concrete bin of 160 tons capacity. Four Fuller pulverisers and a Raymond pulveriser are operated by 75 horse-power motors and have an aggregate capacity of 16 tons per hour. The Raymond pulveriser is served by an exhaust fan driven by a 30 horse-power motor and delivers to a cyclone separator. No separators or dust collectors are used with the Fuller mills, but excess air is removed by an induced draught fan and delivered to the furnace. Screw conveyors feed the pulverised coal to hoppers over the boilers, from which it is delivered to the burners.

Pulverisers and driers are operated continuously. The water tender takes charge of the feeders and the oiler oversees the machinery. Two helpers keep the tubes clean by a steam jet and soot blowers, this operation being performed every four hours. Three men remove ashes from the drier settings, clean the combustion chambers, and remove the ashes behind the bridge wall about once a week. Slag accumulating on the sides of the combustion chamber is removed at intervals of six to ten weeks. Extension furnaces or dutch ovens were added to the boiler furnaces in order to give combustion chambers of ample volume.

As another example of the application of pulverised coal, reference may be made to an electric tramway power station of the Philadelphian Rapid Transit Company. This plant—at Mount Vernon—supplies current for peak loads, and with ordinary methods it involves considerable losses from banking and delays in getting the extra power delivered to the line. It had twenty water-tube boilers of 375 horse-power each, hand fired with anthracite coal, which formerly cost 12s. 6d. per ton delivered. The output capacity is 10,000 kilowatts.

According to a statement by Mr. Rau, power specialist of the company, automatic stokers did not promise any improvement, and oil fuel was considered as a means of reducing the above-named losses and delays. But the present prices of oil are prohibitive, and after further consideration it was decided to adopt the pulverised fuel system, which has the same operating advantages as oil and is independent of any selected grades of coal. The equipment is of the Quigley type. Coal delivered by hopper-bottom railway wagons is passed through a crusher and magnetic separator and then delivered to a rotary drier, from which it passes to two Raymond pulverisers, each capable of reducing three tons of coal per hour to such a degree of fineness that 95 per cent. will pass through a 150-mesh sieve.

Coal, culm, or anthracite can be used, only the cheaper grades being purchased. The labour cost will be less than that required with automatic stokers, and there will be but a low cost for maintenance of the burner apparatus. A saving of 3000 tons of coal annually during banking periods is expected. Mr. Rau thinks it doubtful if pulverised coal can be burned with greater efficiency than bituminous coal of high quality. With efficient furnace equipment and under pre-war conditions there were no special advantages sufficient to offset the additional cost of pulverising. But with the increasing cost of coal and its lack of uniform quality, together with present labour conditions, the use of pulverised coal has become an economical as well as a practicable consideration. At the Mount Vernon plant the saving is expected to be sufficient to cover the cost of installing the pulverised coal system within two years.

The Institution of Civil Engineers.

(1) "DEEP-WATER QUAYS: GENERAL CONSIDERATIONS OF DESIGN."*

By Ernest Latham, M. Inst. C.E.

The paper is restricted to experience on the river Thames and its estuary and to general considerations of design governing the construction of deep-water quays. It is divided into two sections, dealing first with structural considerations, and secondly, with the question of berthing facilities. Present-day costs are referred to as one of the principal factors governing design, and several existing deep-water quays in the Thames are cited.

The relative advantages of open piled structures and quays designed on the "cylinder" system are discussed, and examples are referred to, the "cylinder" system in general being preferred by the author. The driving of fished Oregon timber piles is dealt with, and details of the fish joint and "set" are given. The difficulties of constructing cylindrical piers in deep water are referred to, and the general outline of a deep-water quay now under construction at Thames Haven, Essex, is illustrated. The question of berthing facilities is raised, especially with regard to the difficulties of mooring big ships in tidal waters where there is a considerable range of tide.

The relative advantages of a jetty and dolphins and a continuous quay are reviewed and discussed. The author points out that on a continuous quay face constant attention to mooring ropes is necessary, and an actual example of the mooring of a 12,000-ton ship in the Thames estuary is illustrated. The suggestion of a compromise between a jetty and dolphins, and a deep-water quay, is thrown out, and such a design now under course of construction is given in general outline.

The author concludes by referring to the necessity of constant observation and careful dredging at berths where relatively small ships are only partially water-borne at low water, calling attention to the considerable expenditure involved by the straining of such ships when they touch a hard and uneven bottom.

(2) "THE STABILITY OF DEEP-WATER QUAY WALLS."*

By Francis Ernest Westworth-Sheilds, M. Inst. C.E.

The author points out that, in spite of all that has been written on the subject, no general agreement has been reached as to the best way of estimating the forces and resistances acting on a retaining wall with earth backing and on an earth foundation. The solution of such problems is so unsatisfactory that many engineers discard their calculations, even when they have made them, and trust to their judgment in deciding whether a wall as designed will be stable. This is especially true of deep-water quay walls, whose problems are quite different from those of land walls, owing to the presence of water which creeps underneath and behind them.

A quay wall may be considered as acted upon by certain outward horizontal forces, such as the lateral pressure of backing, &c., which must be balanced by inward horizontal forces, such as the pressure of water in front of wall, the lateral resistance of earth in front of the toe, the resistance due to friction at the base, &c. It is also acted upon by certain vertical forces, of which the downward forces, such as the weight of the wall, &c., must be balanced by the upward forces, such as the upward pressure of water and earth beneath it. Moreover, the sum of the moments of all these forces about any point must be zero, or the wall will overturn. As regards the outward forces, the most important is the lateral pressure of the earth backing, for estimating which engineers generally use Rankine's formula. Mr. Crosthwaite's experiments show that to obtain accurate results with sand the value of φ should be greater than the angle of repose, and Mr. Bell has shown that the formula needs modification in the case of clay. If the backing is flooded, it is suggested that the intensity of its pressure should be estimated as that of water, whose free surface is at soakage level, or of the earth alone, whichever is the greater. Loads on the quay are generally taken at about 2 cwt. per square foot, and heavy point loads may be regarded as dispersed over a certain area. The pull of a ship on the bollards may also be considered as dispersed over a certain length of wall.

As regards the inward forces, it seems right to include the pressure of water in front of the wall at its lowest level. Rankine's formula is generally used for estimating the resistance of the earth in front of the toe, but here again, in the case of sand, φ has probably a higher value than the angle of repose, and clay calls for a modification of the formula. It seems doubtful whether water overlying the earth in front of the toe can be considered as increasing its resistance. A sloping base to a wall would appear to produce an inward resistance. As regards friction between the wall and the earth beneath it, this is generally obtained by deducting the other inward forces from the outward forces. The result ought to be definitely less than the permissible friction, which is usually estimated by multiplying the weight on the base, less the upward pressure of water under it, by a suitable coefficient. Such coefficient in the case of clay may be little or nothing. The vertical downward forces are generally assumed to include all materials—masonry, earth and water, directly over the base. The friction between the backing and the back of the wall is usually ignored, though in certain cases it may come into play. The upward vertical forces are generally assumed to include pressure of water under the base due to a head equal to the height between the base and the lowest water level. The friction between the toe and the earth in front of it is commonly ignored. The remaining force, which is the upward resistance of the earth under the wall, is found by deducting the other upward forces from the downward forces. Then by taking moments of all forces about any point, the position of the resultant of this earth resistance can be found, and hence its greatest intensity. This again should be definitely less than the permissible resistance or bearing power of the earth, which is estimated in various ways, and in many cases can be determined by experiment.

Some devices for stabilising a wall, such as widening or deepening it, stepping its back, lengthening the toe, removing part of the backing, are considered from the standpoint of theory and of experience. It is suggested that as there is now a large amount of information available about the behaviour of quay walls under various conditions, such information should be collected and analysed, with a view to laying down satisfactory rules for wall design.

* Official abstracts of papers read at the ordinary meeting of the Institution on Tuesday, December 13th, 1921.

CAST IRON RESEARCH.

The following report has been issued by the Cast Iron Research Association:—

During the month of November members have sought advice on a number of problems the majority of which are of common interest to the industry. In the matter of cupola practice the questions of correct fluxing slags for de-sulphurising purposes, of extraordinary addition to the slags of de-sulphurising agents, the influence of fluxes on cupola erosion and iron losses, have been dealt with. Aid has been sought in the correct apportioning of charges of differing types of pig iron, in the best methods for the elimination of sulphur from impure scrap, and in determining the limit of melting fatigue through repeated re-melting.

Abnormal fractional (*sic*) and abrasional (*sic*) wear in gearing and piston rings, and difficulties in chilled castings have been investigated and correct mixtures and analyses suggested. Where sand mixtures or preparation of the mould have led to defects in cases submitted, examination of the sands has been made and modifications suggested to overcome such defects. Further work has been done in the sand research problem and is in progress. The manufacture and treatment of annealed cast irons for high-speed machining has had attention, and investigation on the reason for serious defects in certain types of large engines and machine castings are still being continued. Further data have been accumulated for the research on "shrinkage and draw hole" phenomena and towards the pig iron grading problems.

Generally, as in the previous reports, the difficulties brought before the Director for assistance have very materially enriched the records of the Association, and have pointed the way to fresh avenues of investigation and research.

ELECTRIFICATION OF ITALIAN RAILWAYS.

It is announced from Rome that a report has been laid before the Senate relating to the authorisation given to the Railway Administration to raise a sum of 440 million lire for special works. At the present moment electric traction is employed on 539 kiloms. of line with a length of rails aggregating 1045 kiloms. The complete electric plant is about to be put into operation for the whole Ronco line, thus completing the electric equipment for the entire Turin-Rome line. The electrification of the direct lines Ronco-Arquata-Tortona, Tortona-Novi, Voghera-Bivio-Bormida and Genoa-Ovada-Alessandria has been begun. It is hoped to complete very shortly the electrification of the Rome-Tivoli and the Rome-Anzio-Nettuno lines, after which the works for the electrification of the direct Rome-Naples line will be pushed on. Thus at the beginning of 1923 another 500 kiloms. of electrified lines may be completed with 1370 kiloms. of rails.

But since the electrified lines would be useless without electric locomotives, and the construction of the latter takes from eighteen to twenty-one months, the Railway Administration has been obliged to give orders already, beginning with one for 111 locomotives, at a total estimated cost of 165 million lire. Some of these locomotives will be used to complete the equipment of the lines already in use, and the remainder will serve for those in course of electrification. The proportion of the 111 locomotives, however, destined for use on the lines to be electrified by the beginning of 1923 is considered insufficient by the Railway Administration owing to the great impulse given recently to the work of electrification. In view of this insufficiency and the time required for construction, the Government has deemed it necessary to authorise the Railway Administration by a decree law to raise 169 million lire for the acquisition of 120 additional electric locomotives.

According to the Board of Trade returns, the value of the railway material exported during the ten months ended October 31st last was as follows, the corresponding figures for 1920 and 1919 being added in brackets:—Locomotives, £6,594,963 (£4.407,201, £1,120,025); rails, £2.429,468 (£2,144,720, £1,570,913); carriages, £1,322,379 (£1,411,838, £395,420); wagons, £4,979,776 (£4,752,725, £1,483,917); wheels and axles, £1,456,632 (£1,566,002, £594,553); tires and axles, £1,107,752 (£1,124,491, £748.374); chairs and metal sleepers, £1,119,361 (£1,019,459, £294.427); miscellaneous permanent way, £2,242,652 (£1,944,361, £639,237); total permanent way, £8,581,597 (£7,907,991, £2,535,036). The weight of the rails exported was 122,702 tons (107,703 tons, 97,752 tons), and of the chairs and metal sleepers, 46,541 tons (47,337 tons, 20,366 tons). Locomotives to the value of £187,034 were shipped to India during October, and of £114,340 to South Africa. Rails to the value of £69,190 were exported to India, of £65,073 to the Argentine, and of £25,221 to South Africa.

Railway Electrification.

By Sir VINCENT L. RAVEN, K.B.E., M. Inst. C.E., M.I. Mech. E.*

No. I.

ADMITTEDLY, the practical experience of locomotive engineers in this country has been almost exclusively confined to the steam locomotive, and for that reason it would probably be well to enumerate in the first instance the mechanical limitations and disadvantages which, every engineer will agree, exist in the steam locomotive, and which, it may be argued, are overcome to a very considerable extent by the adoption of the modern and more up-to-date system of electric traction.

The mechanical disadvantages of the steam locomotive may be briefly summarised as follows :—

The locomotive being a complete independent unit, its power cannot be greater than the capacity of the boiler.

To increase the boiler capacity obviously implies increased dimensions and weight, both of which offer grave difficulties in regard to clearances and strengthening of bridge structures.

It is known that on many railways in Britain the limit of weight has been reached, and further development of power is only possible at enormous expense.

The boiler, cylinders, valve gear, crank shafts and all reciprocating parts are costly to maintain. Turntables, fuelling plant and water supply appliances must be provided.

The cab is small and open to the weather, involving discomfort to the locomotive crew.

The locomotive radiates heat and uses coal all the time steam is up, that is, during many hours when it is doing no work and either standing by or coasting.

The wear and tear of the locomotive on the track is considerably increased by the impossibility of accurately balancing the reciprocating parts.

The case for the electric locomotive may be set out by the brief statement that it is not hampered by any of the above-mentioned objections. In addition, one might point out that it possesses other important qualifications, such as :—

Simplicity of mechanical construction and operation.

Increased power of acceleration.

Higher scheduled speed due to the possibility of heavy short-period overloads, resulting in more frequent service and increased use of existing tracks.

Uniform turning effort resulting in better factor of adhesion at starting and on gradients.

Absence of all reciprocating movement and accurate balance of all rotating parts.

Facilities for driving from either end of a locomotive.

Accessibility of mechanical and electrical parts.

Better accommodation for locomotive crew by reasons of increased cab area and by closing in and heating the cab.

Possibility of coupling two or more locomotives together under the control of a single driver.

One essential difference in operation between an electric and steam locomotive, where the former can show a very definite advantage, lies in the preparation and setting by of the locomotive.

An electric locomotive is always available for service at a moment's notice, since the electric motors only require that they should be kept clean, lubricated and provided with brushes in order that they may be always ready for immediate use by simply connecting them to the distribution line. When the day's work is over, nothing has to be done except ordinary examination, oiling and cleaning for next trip.

On the other hand, the process of preparing a steam engine for duty involves considerable time and labour. About three hours before the driver and fireman come on duty, the steam raiser has to make up and light the fire and attend to it until the driver takes charge, after which it takes the driver and fireman about sixty minutes to complete the preparation of the engine for its day's work. While the engine is at work, water and coal have to be taken, and very often the fire has to be cleaned and made up. After the day's work is finished, the fire has to be thrown out and fire-bars cleaned, smoke box ashes to be thrown out of the smoke box, and the tubes have to be cleaned by compressed air. The top of the brick arch has to be cleaned down, and the brick arch itself has to be renewed frequently. About every sixth trip, the boiler washer has to clean the boiler to keep it fit for producing steam. The boilersmith has to examine and renew the lead plugs and attend to leaky tubes and many of the other small repairs to the boiler in order to enable the engine to run its stipulated mileage. The shed fitters have a large number of working parts to keep in order which have no corresponding part on an electric locomotive.

Then, again, when the electric locomotive has been put into service it can remain at work continuously for at least twenty hours in every twenty-four, as the lubrication and the small amount of cleaning that is necessary for the electrical equipment can be given by the crew at wayside stops, during reunning and between trips.

It may be contended that the driver will be fully occupied during running in watching signals and controlling speed, and will not be able to attend to these small items ; but it must be remembered that, although a second man is not required in the operation of an electric locomotive it has so far not been usual to allow one-man operation. This means that the second man in the cab will have plenty of opportunity to attend to cleaning and inspection of all parts where this can be done without interfering with the running.

Therefore, an electric locomotive need only go into the sheds in the ordinary way for cleaning and inspection of brake blocks and certain of the less accessible parts between the frame. On the steam engine, however, the boiler, fire and smoke box, in addition to the much larger number of mechanical parts, such as cylinders, valves, link motions, &c., are responsible for a considerable amount of time taken up in examination, and attention which might otherwise be utilised for hauling traffic.

Here it should be said at once that although the electric locomotive may be capable of remaining in service for a longer period of the day than the steam locomotive, it is not possible to obtain the full advantage due to this feature without adopting some system of "pooling." It is evident that the crew of the electric locomotive, even though their duties are very much lighter than those of the crew of a steam engine, cannot remain at work for a longer period, owing to present-day regulations. This might be held to neutralise to a large extent the particular advantage of the electric locomotive, but it would seem on examination that the objections which are made to "pooling" of steam engines do not hold good in the case of electric locomotives. Due to the simplicity of control, in the case of the electric locomotive, there is no objection to "pooling," and so full advantage can be taken of their capacity for working longer hours.

In addition to this, since the only requirements of the electric locomotives in the ordinary condition of service consist of cleaning and adjustments carried out in the ordinary routine inspection, it is possible when some occasional derangement of schedule occurs to keep these engines in continuous service for two or three days, by omitting the cleaning and routine inspection for that period. This advantage applies particularly to the case of the electric shunting locomotives, which are frequently kept in service for six days continuously.

The following examples may be quoted to illustrate the possibility of utilising this advantage of the electric locomotives :—

(*a*) On the Chicago, Milwaukee and St. Paul line passenger locomotives run through from Harlowton to Avery, a distance of 440 miles. When the gap between Avery and Othello is electrified the same engine will run through from Harlowton to the Pacific Coast, a distance of about 850 miles.

(*b*) On the Norfolk and Western Railroad in the last six months of 1918 the average mileage worked by each of twelve electric locomotives was 22,250, some 3700 miles per month, compared with steam engines on the same line which worked some 1500–1600 miles per month. The average engine hours worked per day were eighteen to twenty in the last six months of 1919.

(*c*) On the New York, New Haven and Hartford Railroad the average mileage worked per day by electric locomotives is shown on the following table. These figures are very high as compared with steam practice.

New York, New Haven and Hartford Railway.—Average Mileage Worked per Day by N.Y., N.H. and H.R. Electric Locomotives compared with N.E.R. Steam Locomotives.

	Passenger.	Goods.	Shunting.
All locomotives—			
September, 1915	183.63	105.88	113.01
April, 1919	201.30	81.61	98.84
N.E.R., 1919	51.58	46.11	80.53
Serviceable locomotives—			
September, 1915	214.98	122.96	129.15
April, 1919	229.40	103.50	112.96
N.E.R., 1919	91.84	61.50	101.27

(*d*) On the North-Eastern Railway the result of the Newport and Shildon working between 1914 and 1920 is in accordance with the following statement :—

Newport and Shildon Electrification.

	Train miles per train hour.		Wagon miles per train mile.		Wagon miles per train engine hour.	
	1914. Steam.	1920. Elec.	1914. Steam.	1920. Elec.	1914. Steam.	1920. Elec.
January	6.3	7.9	45	54	203	358
February	6.3	8.6	44	55	204	390
March	6.6	8.6	43	54	206	388
April	6.4	9.0	43	53	202	390
May	6.5	9.3	44	51	206	385
June	6.7	8.8	43	53	211	377
July	6.4	9.3	45	52	214	390
August	6.6	8.5	43	53	210	367
September	6.5	8.8	45	52	212	367

I have also taken out some figures for this branch showing the mileage run by the electric engines to day, which is 116 train miles per day per engine in traffic, as compared with 55 for the steam engines in 1914.

The working of a steam engine depends to a large extent on the skill of the crew in attending to the fire and the water level, and in looking after a large number of mechanical parts, and generally nursing the engine so as to get the best out of it. The working and condition of an electric locomotive is not nearly so dependent upon the skill of the driver and his assistant. Full power is always available, and the power and speed which can be developed at any moment are only limited by the initial design of the electrical equipment and by the mechanical construction.

The limitation of boiler capacity in the case of a steam engine combined with the different characteristics of steam and electric locomotives gives the latter an additional advantage in the question of speed on gradients. As the governing factor in the power of a steam engine is the capacity of the boiler, which is practically a fixed quantity, the horse-power output of the locomotive is approximately constant over a wide range of speed. In other words, the maximum pull of an electric locomotive can be maintained until a certain definite pre-arranged speed is attained ; whereas a steam locomotive can only exert its maximum pull at the moment of starting, after which the pull is reduced as the speed increases. In the case of our 0–8–0 mineral engines, the reduction in the maximum pull is about a quarter of a ton for each mile per hour that the speed is increased. So that if the maximum pull at the moment of starting is 13 tons, the maximum pull when the engine is going at twelve miles per hour will be 10 tons. Thus the speed of the train falls to a marked extent whenever the train has to climb a gradient. This reduction of speed on a gradient is not nearly so marked in the case of the electric locomotive, for there being no similar limitation to the amount of power available, the relation between speed and tractive effort is quite different, and the demand for greater tractive effort is supplied by a higher output from the power supply system. Thus, when determining the initial characteristics of an electric locomotive for a given service, the speed up the ruling gradient can be fixed at any desired value ; and since the efficiency is practically constant over a wide range of load, the speed on the level can be maintained at the same value, if desired, without loss of efficiency. In comparison with the steam engine working, where the speed is greatly reduced on a gradient, this enables a much higher average speed to be maintained over the whole line, which is equivalent to saying that with electric working the general average speed can be considerably increased without any increase in the maximum speed.

If other factors, such as draw gear and braking facilities permit, this characteristic of electric locomotive operation would allow goods trains to travel at an average speed more nearly approaching that of passenger traffic. The result of this would be a more regular flow of traffic over the line and the necessity for side-tracking the goods trains to allow passenger trains to pass would be reduced. It is a fact that a higher general average speed of travel increases the total capacity of the line.

A further advantage which can be obtained owing to this increased average speed of travel is better traffic working. In dealing with the traffic carried, a greater number of trains can be run, and these trains complete their journeys in less time than with steam working, thus enabling better use to be made of the available rolling stock. This is particularly true in the case of goods wagons. The percentage increase in the speed will be greater in the case of the goods than in the case of the passenger trains, and so the saving in wagons, due to the increased mileage which wagons will be able to work annually, will be particularly striking.

Partly as a result of the increased average speed, and partly as a result of the longer time that electric locomotives can be kept in service as compared with steam engines, a considerable saving can be effected by electrification in the total number of engines that are required to deal with any given volume of traffic. As an example of the saving of locomotives, the following table may be given showing what has been done on the Chicago, Milwaukee and St. Paul Railway :—

Chicago, Milwaukee and St. Paul Railway.—Steam Locomotives replaced by Electric Locomotives (Missoula and Rocky Mountain Divisions).

	Passenger.	Goods.	Shunting.	Total.
Number, steam	19	85	8	112
electric	12	30	3	45
Average steam tons	164	188	106	—
Weight electric tons	269	257	63	—
Total steam tons	3,120	16,000	848	19,968
Weight electric tons	3,230	7,720	190	11,140

Mr. Beeukes, the electrical engineer to the railway, has estimated from actual records that electrification has enabled about 30 per cent. more tonnage to be dealt with in about 80 per cent. of the time formerly required under steam operation, which means an effective increase in the capacity of the line due to electrification of 32.5 per cent. These figures give some idea as to the effective increase in the capacity of the line due to electrification.

Due to its uniform turning efforts, the electric locomotive has a further advantage when starting trains. In the case of the electric engine, the increase of the effort at starting above the normal effort is greater than in the case of the steam engine, and can be kept up for a longer time.

If an electric engine stands for an hour on an up gradient there is no reduction in its maximum pull. When a steam engine stands for some time the cylinders are cooled, and the engine cannot exert its maximum pull until they are heated to about the temperature of the entering steam. It has been observed that this reduction of pull due to cooled cylinders is as much as 25 per cent.

As there is no necessity for taking in water for electric locomotives—with the exception of the small quantity that may be required to steam heat existing passenger stock in certain cases—it is unnecessary to provide either water columns or troughs on lines designed for electric operation. Similarly, there is no need to provide coaling stations, coaling plant or ashpits for electric operations. Again, electric locomotives are designed for double end driving, and there is no need for turntables or the delays in turning engines. Thus, in these items time can again be saved and added to the useful working time that the engine is in service. Further, because the electric locomotive requires no attention whatever while lying by, a saving can be effected in the crew's time, since it is unnecessary for an electric locomotive to be in charge of the crew while it is lying over. It can be locked and left in a safe place. In the case of a steam engine the time occupied in ineffective locomotive duties is over 25 per cent. of the total enginemen's time, as shown by the Ministry of Transport's figures for North-Eastern engines.

A very serious disadvantage of steam operation is that the steam engine radiates heat and uses coal all the time that steam is up, that is, during many hours when it is doing no work, and either standing by or coasting. On the other hand, the electric locomotive uses no power whatever—except for lighting and heating the cab—unless actually running and doing work. It is quite evident that for this reason electric operation makes possible a very considerable saving in fuel as compared with steam operation. This saving is all the more important in proportion as the duty performed by the engine is the more intermittent, especially since the electric locomotive has a much higher efficiency when only partly loaded than the steam engine.

It has been shown that a saving is effected due to less consumption of power in idle time, but the main fuel saving which can be introduced by electric operation is due to the very much more efficient combustion of the fuel that can be obtained under the boilers of modern coal-fired power stations than is obtained by burning relatively small quantities of coal on the individual engines.

The figures at the top of the next column were compiled for the Rocky Mountain Division for steam operation during October, November and December, 1915, and for electric operation on the same division during the same months in 1916.

From the figures in this table it is clear that one unit of electrical energy delivered by the power company to the

* Abstract of a paper read before the North-East Coast Institution of Engineers and Shipbuilders.

railway company's line does the work of between 6 lb. and 7 lb. of coal on steam locomotives. It is well known, with an up-to-date power station, a unit of electricity is produced with less than 2 lb. of coal.

Chicago, Milwaukee and St. Paul Railway.—Comparison between Coal used for Steam Working and Energy Purchased for Electric Working.

	October.		November.		December.		Average.	
	1915. Steam.	1916. Electric.	1915. Steam.	1916. Electric.	1915. Steam.	1916. Electric.	1915. Steam.	1916. Electric.
Passenger traffic—								
Units purchased per train mile	—	30.3	—	27.4	—	29.0	—	29.1
Pounds of coal used per train mile	171	—	201	—	193	—	188	—
Ratio, pounds of coal per unit	5.63		7.34		6.46		6.46	
Freight traffic—								
Units purchased per 1000 gross ton-miles	—	37.4	—	39.1	—	42.0	—	39.4
Pounds of coal used per 1000 gross ton-miles	247	—	294	—	291	—	276	—
Ratio of pounds of coal per unit	6.61		7.52		6.93		7.01	

This is the result obtained on a railway which is exceptionally well suited to electrification owing to the nature of the line, which passes over two or three ranges of mountains; but although an equally good result is hardly to be expected on a railway such as the North-Eastern, where the greater part of the line runs over fairly flat country, the saving in fuel that would be realised on this line would still be very substantial. Careful calculations show that as a result of electrification the weight of the low-grade coal that would have to be burned in the modern electric power station, from which energy would be taken for working the traffic electrically, would not be more than 40 per cent. of the weight of high-grade coal used on steam locomotives to do the same work. On this basis, if we take the North-Eastern coal consumption in 1919—which was 921,480 tons—we find that if electric working were substituted for steam there would be a saving of about 550,000 tons per annum, and a further saving would be effected due to the fact that the low-grade fuel would be substantially cheaper than the high-grade locomotive coal.

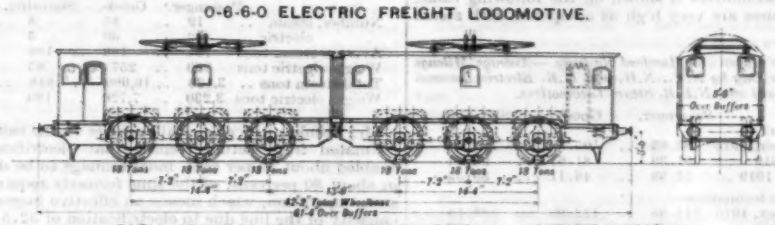
In addition to this, a large proportion of the standing charges would be saved, as the electric locomotive requires much less attention than the steam engine, and the cost of repairs and maintenance would be considerably reduced. In a paper read before a joint meeting of the American Society of Mechanical Engineers and American Institute of Electrical Engineers at New York, on October 22nd, 1920, Mr. Armstrong, chairman of the Electrification Committee of the General Electric Company, gave the following table of electric locomotive maintenance for the year 1919:—

Electric Locomotive Maintenance Data for 1919.

	New York Central Railroad.	Chicago, Milwaukee and St. Paul Rly.	Butte, Anaconda and Pacific Railroad.
No. of locomotives owned	73	45	25
Locomotive weight, tons	118	290	84
Annual mileage	1,946,879	2,321,148	566,977
Cost of repairs per mile, cents	6.39	14.65	6.48

As compared with these figures, Mr. Armstrong gives the present cost of maintaining a 2–8–8–2 "Mallet" steam engine at 60 cents per engine mile, without including many miscellaneous charges not shared by the electric locomotive.

On the Newport and Shildon line, a comparison of costs



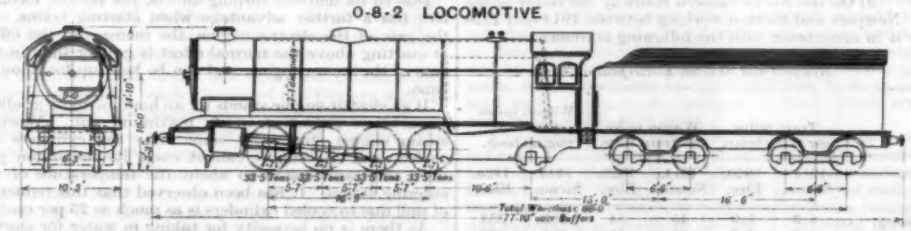


FIG. 1—COMPARISON OF STEAM AND ELECTRIC LOCOMOTIVES

by fuel losses inherent in steam engine operation may be eliminated in electric operation. To gain some idea of how great this saving may be, an analysis was made of certain heavy gradient runs on the Chicago, Milwaukee and St. Paul Railway made by steam operation, in which it was found that the stand-by fuel losses amounted to 27½ per cent. of the total coal burned. This saving of fuel burned on the steam locomotive has an additional value from the traffic point of view in addition to the actual saving in the cost of fuel, for the coal that is saved would have had to be carried over the line to a number of engine coaling depôts.

With electric operation, a much smaller tonnage of coal has to be carried over any line—for the same traffic—and this quantity is carried to fewer unloading points, namely, the power stations. This results in the clearing from the line of a number of local trains. A number of wagons will also be set free which, with steam operation, would have to be employed in carrying coal. In the example quoted previously, where the calculated savings were given, resulting from the electrification of a certain section of line, it was estimated that there would be a saving of ninety-three 40-ton wagons due to the reduction in fuel consumption.

On lines where the gradients are long and severe, the equipments of electric locomotives can be arranged for the generation of power, so that when a train is descending a gradient the motors become electric generators and return power to the distribution system, and in so doing produce a retarding force, holding the train on the gradient without the use of the mechanical brake.

The regenerative braking may be a very definite advantage in certain cases of lines where heavy gradients occur, and it is peculiar to electric operation, no similar effect being possible with steam working.

Resulting from the experience which has been obtained of electric locomotive operation in America, it can be definitely stated that electric locomotives show a considerable advantage over steam engines in the cost of repairs and maintenance. In a paper read before a joint meeting of the American Society of Mechanical Engineers and American Institute of Electrical Engineers at New York, on October 22nd, 1920, Mr. Armstrong, chairman of the Electrification Committee of the General Electric Company, gave the following table of electric locomotive maintenance for the year 1919:—

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On the Newport and Shildon line, a comparison of costs of repairs has been got out, and show as under, the steam engines being those which used to work this traffic.

	Steam, No. 1682, 0–8–0 type goods.	Steam, No. 1139, 0–6–0 type goods.	Electric, No. 9, 0–4 + 4–0 type.
Material	£267 9 11	£533 16 2	£98 0 9
Wages	£455 15 3	£434 0 2	£258 5 1
Shop expenses	£341 16 6	£325 10 1	£193 14 5
Total	£1065 1 8	£1293 6 5	£550 9 3
Miles run between repairs	51,134	56,210	100,101
Cost per mile	5.000d.	5.522d.	1.316d.

It may be noted also that the steam engine had no special renewals due to the boiler, otherwise the cost would have been very much higher. The latest passenger locomotives on the Chicago, Milwaukee and St. Paul line are taken off for inspection after a mileage varying from 3000 to 5000 miles.

It may be argued that the whole story is not complete when one compares the maintenance cost of an electric locomotive with that of a steam engine, as there is obviously a charge to be added to the electric for generating at the main station, and also transforming at the sub-stations, together with the equipment of the permanent way. It must be remembered that the cost of coal and water has not been added to the maintenance of the steam locomotive; therefore, to make the whole story complete, so far as a comparison between the two is concerned, you would have to take the maintenance of the steam engine together with the coal and water used, and compare that with the maintenance of the electric engine and rail equipment, and the total cost per unit; which, of course, includes coal and maintenance of generating and sub-stations. In the figures which we have for the North-Eastern Railway, the cost of coal and water used by the steam locomotive is somewhere equal to the unit as supplied to the electric locomotive, together with the cost of maintenance of permanent way.

I have gone into the matter carefully with the figures obtained in regard to the Chicago, Milwaukee and St. Paul Railway, and it appears that the cost of coal on the locomotives is 40 per cent. greater than the cost of the power delivered to the locomotives, all expenses in connection with generation, transmission, conversion and distribution being included in the cost of power, together with capital charges and depreciation. Therefore, when this is taken into consideration, it would appear that the comparison of cost of maintenance, as has been shown between the two types of locomotives, is, at any rate, a fair one. In the case of the North-Eastern Railway it can be shown, as mentioned above, that the cost of coal and water on the locomotive will balance the cost of the power delivered, including all the expenses before mentioned.

It will be seen that an additional saving of 40 per cent. is shown on the Chicago, Milwaukee and St. Paul Railway, but this can be accounted for. The power supply is almost entirely generated in hydro-electric stations, and the water power resources consequently reduce the cost of the power delivered to the locomotives. Even though these costs for the North-Eastern Railway balance, the advantages gained by electric motive power increasing gross earnings and decreasing operating and maintenance expenses are sufficient to guarantee the adoption of electrification.

Wherever it may be necessary to have recourse to double heading, this can be more easily and satisfactorily done with electric than with steam engines, for two electric engines can be readily coupled electrically by a low-voltage control cable, and when this is done the two locomotives can be operated by one crew, precisely as if they were one locomotive, in a similar manner to the operation of the various motor coaches on a multiple unit train by one motor man. Double heading with steam engines cannot be worked with only one crew, and is subject to the difficulty of synchronising the various operations. Again, so far as the comfort of the crew is concerned, the electric locomotive is superior to the steam engine.

In very cold weather the electric locomotive has another advantage, in that it is not subject to the effects of radiation and freezing, as is the steam engine; while in hot weather the dangers of starting fires in the dry vegetation alongside the track by cinders falling from the engine is non-existent. The cost of compensation to owners located along the route of a railway in this country, due to fires caused by the hot ashes discharged from the uptake of a steam locomotive, is considerable, particularly during a period of drought such as recently experienced. Again, the entire absence of smoke and dirt from the electric locomotive may be a decisive advantage in certain classes of terminal lines or where there are numerous or long tunnels to be traversed.

I have endeavoured to show in this paper the great advantage of being able to build or design a locomotive which by its tractive effort is able to keep a more uniform speed over the railway. In order to do this, it is necessary that you should be able to design a machine capable of giving you the power within the limits of the present load gauge. With a view to showing the difficulty of increasing the power of a steam locomotive without exceeding these limits as they stand to-day, I have worked out and show in diagram form—Fig. 1—an electric locomotive capable of exerting a pull of 15 tons, which would haul a train of 1000 tons up a gradient of 1 in 100 at 30 miles per hour, which is something, I think, we ought to aim at in the future; also a steam locomotive for dealing with the same work.

It will be seen from the above that the one is within our present gauge and the steam unit considerably outside, and would be impossible to build unless a large amount of money were spent over widening the line and altering bridges and stations. It would require three of our two-cylinder 0–8–0 locomotives to do the work of this electric locomotive.

A good deal of controversy has taken place recently amongst the engineers and traffic superintendents as to the advisability and cost of adopting the international Berne gauge in this country, but the cost is so prohibitive that the question has been dropped for the present. Although electric traction would not get over the difficulty of dealing with larger coaches, it would get over the difficulty of designing more powerful locomotives without increasing the gauge.

(To be continued.)

British Engineering Students in France.—It may interest our readers to hear that French engineering firms of the Lorraine district (rolling stock, railway material, &c.) having kindly consented to accept for periods of two or three months a few British engineering students during their summer holidays, applications, in writing, stating age, qualifications, and giving references, will be received (until further notice) by the Hon. Secretary, 'British Section Société des Ingénieurs Civils de France, 45, Great Marlborough-street, London, W. 1. The students will not receive any salary and will make their own arrangements for the journey, board and lodgings. Local members of the Société will give advice in these matters if desired. The students, in their own interest, will undertake to submit to the same discipline and working hours as their French colleagues on the works' staff. Some knowledge of the French language is advisable.

Crystal Palace Engineering Society.—The "Wilson Premium" for the best paper read before this Society during the past session has been awarded to Mr. B. W. Rowe for his paper entitled "Road Construction." Other papers read and discussed during the session were "Electric Traction," by W. A. Reynolds; "The Ruby Mines of Persia," by E. N. Wemyss; "Sewage Disposal," by D. M. Cameron; "Refrigerating Machinery," by E. A. Wheeley; and "Water Power," by T. L. Bowning. The Premium was handed to Mr. Rowe by General Sir Edward Raban, K.C.B., late Director of Works to the Admiralty, on the occasion of the 147th distribution of certificates, at which he presided on December 21st. Sir Edward, in his address to the students, said that they were living in difficult times, and there was a deficiency of work in civil engineering, and he advised them, on leaving, to take any class of work under a contractor they could get to gain experience. He also strongly urged the importance of young engineers making clear and good reports of work in hand, because those employing them often had no windows out of which to look upon the work. Young engineers had no idea how the ability to write a good report would help them in their profession.

A Seven-Day Journal.

Reduction of Railway Rates.

MUCH disappointment has found expression at the comparatively meagre concessions in railway rates now announced by English and Welsh companies. The Scottish companies will apparently take independent action. The demand of the trading community formulated at recent interviews with railway managers was for a general reduction to about 50 per cent. over pre-war level as compared with the existing level of over 100 per cent. Railway managers found themselves unable to take this bold step, and have decided for an experimental period of a year to give a reduction on coal, coke and patent fuel and on some raw materials of the iron and steel and chemical trades down to 75 per cent. above pre-war level. The flat rate, which it was hoped might be abolished, is reduced by one-third, but the maximum addition is, where applicable, to be retained. The rest is silence. We are told that these concessions will cost the railways £10,000,000 a year, as there is apparently no expectation that the reductions will prove a real stimulus to traffic. The natural inference will be that railway managers have either conceded too much or too little. A bolder policy which would have assisted a trade revival might, in spite of the risk involved, have proved a wiser step in the long run. As it is, nobody is satisfied. The hope is expressed that with a fall in the railway wages bill and lower prices for railway material, fresh consideration will be given to the subject. There is already talk of an appeal by traders to the Railway Rates Tribunal.

Shipbuilding Outlook.

IMPROVED conditions in the shipbuilding industry are apparently postponed for some time to come. It is welcome news, therefore, that a sale having been made of four large ships on which work had been suspended at the Tyne yard of the Northumberland Company and the Doxford yard on the Wear, the construction of these vessels has been resumed in order to give delivery early in 1923. All the ships are vessels of about 10,000 tons, but owing to high costs the Norwegian owners ordered the work to be stopped some months ago. It should be mentioned that the sale to a British firm of shipowners has been made at about pre-war prices, so that a heavy loss will have to be shouldered by somebody. The importance of the deal lies in the fact that it will enable employment to be found for a considerable number of men during the winter months.

Tidal Wave on East Coast.

THE disaster which caused such damage at the port of Hull on Saturday last is an almost unparalleled occurrence in this country. The flood which swept through the streets of the city and caused damage estimated at between £500,000 and £750,000 was the direct result of a very high tide in concurrence with a strong easterly gale which maintained a large volume of water in the Humber estuary. The result was that the river Hull, which is a tributary of the Humber and the channel of which is adjacent to the low-lying parts of the city, received such a volume of water that the banks burst and flooded the old portion of the city, and many of the principal buildings and thoroughfares. The Town Hall, Post Office, Holy Trinity Church, St. Mary's Church, and other buildings were flooded to a depth of several feet. The North-Eastern line from Hull to Goole and Selby, which for several miles is carried along the banks of the Humber, was also flooded, and at one time railway communication was interrupted. Tramway services in the old town were suspended, and at one time it appeared probable that telegraphic communication would cease owing to damage to telegraph cables. Telephonic communication and the supply of electric current were disorganised. Somewhat similar conditions prevailed in the Tyne, where a large floating crane broke loose from its moorings and, drifting down the river, did considerable damage, colliding with more than one vessel before sinking in the river.

Mersey Bridge or Tunnel.

THE question of improving cross-river communication still continues to attract attention in the Liverpool district. Reference was made in a recent issue to the proposal of Mr. Arthur Maginnis to convert the existing Mersey Railway tunnel into a roadway with access to the surface on both the Birkenhead and Liverpool sides of the river. There is, however, a strong movement in favour of constructing a high-level bridge, although it is recognised that, partly by reason of the character of the work and the lengthy approaches which would have to be constructed, it would prove a costly project and could not be completed for some years. The advantage of utilising the existing tunnel is that it could be made available for road traffic in the comparatively near future, when, in any event, some relief from the existing congestion must be provided. In spite of all that has been done by local authorities to improve the ferry goods service by the construction of new boats and better landing stage facilities, it is clear that these are only expedients and not remedies for traffic congestion, which is bound to assume an acute form again at no distant date. Alderman Quinn, the Mayor of Wallasey, has made the practical suggestion that instead of concentrating the ferry traffic from all points on Liverpool Pier Head, use should be made of landing places and ferries at the north and south ends of the dock estate.

Warship Construction and Shipbreaking.

THE problem of unemployment at the dockyards has been the subject of questions in Parliament. There was a hope in some quarters that the smaller displacement of the new capital ships authorised under the agreement at Washington as compared with the four vessels for which contracts were placed recently would enable the construction to be undertaken in the Royal dockyards. A definite question on this point having been asked on behalf of Devonport, it has been stated that it would not be practicable to build the new battleships at that dockyard. An impression prevails in well-informed quarters that the contracts will eventually be placed with private firms to compensate for the cancellation of the earlier orders, if for no other reason, and that an endeavour will be made to provide employment at the dockyards by allocating shipbreaking work to those establishments.

Ventilation of Blackwall Tunnel.

CONSIDERATION is being given by the London County Council to the adoption of a scheme at a cost of £7000 to improve the ventilation of Blackwall Tunnel. For some years after the construction of the tunnel no need for the adoption of any special scheme of ventilation was revealed, the small gratings which had been fixed serving the purpose. The growth of mechanically propelled traffic has, however, introduced new conditions, and whereas in past years the occasional presence of fog in the tunnel was not associated with any real inconvenience, it was found during a recent period that the association of petrol fumes and other gases with fog made conditions in the tunnel so bad that workmen and others were overcome. The plan suggested for the improvement of the ventilation is the installation of electrically operated fans in one of the tunnel shafts.

Empire Airships.

DEVELOPMENTS during the past few days suggest that the scheme for Empire airship services may, after all, be realised. It is understood that capital to the amount of £2,500,000 will be found to put experimental services into operation if Great Britain and the Dominions will provide a sum of £1,000,000 for the establishment of airship bases, the repair of two or three existing airships and other preparatory work. The offer to provide private capital is also contingent on Great Britain granting a subsidy of £250,000 and the Dominions a similar sum for a period of years. Those who believe that airship services on Empire routes are a commercial possibility are pressing this offer on the Government, but it is impossible to make any prediction as to the course of events. There are apparently only two vessels which are capable of carrying out long-distance flights, the R 33, which is in a good state of repair, and the L 71, a surrendered Zeppelin, which would, however, require considerable repairs to put her in a condition to make long flights. Those who are behind the Empire scheme point out that plans are being made by a Spanish-German combine for airship services between Europe and South America, to commence in 1923, and that immediate action by Great Britain and the Dominions is necessary if we are not to be put in a position of inferiority. Mr. A. N. Ashbolt, the Agent-General for Tasmania, is taking great interest in the scheme which is now in making.

New West Country Canal.

A SOMEWHAT novel proposal has been put forward for an addition to the British canal system. It seems hardly likely that the capital will be provided from State sources for a new inland waterway, having regard to the difficulty of obtaining State aid for the improvement of the existing canal system. Those behind the new project are, however, emphatic as to its utility in the national transport system. The provisional plans are for a canal either from Bridgwater to Exmouth, or from Bridgwater to Poole, with the object of opening up a new route for waterborne traffic from the Bristol Channel to destinations on the south and east coasts or near continental ports. In the case of the Bridgwater-Exmouth scheme the route would be *vid* Taunton, Tiverton and Exeter, and thence by the river Exe. The second route would be from Bridgwater through Yeovil and Blandford to Poole. A third route has been suggested, from the river Brue between Bridgwater and Weston-super-Mare along the course of that river to Glastonbury and thence to Blandford. The estimated cost of the canal is £30,000,000, and the time of construction is put at ten years. An argument in favour of the scheme is that it would provide employment for many thousands of men.

Wireless Telephone Developments.

AN interesting demonstration of telephonic communication, partly by line and partly by wireless transmission, has been given by the Marconi Company during the past few days. For the purposes of this test Marconi House was linked up by the ordinary trunk line with the wireless station at Southwold. Transmission from there was by wireless to the wireless station at Zandvoort, and thence by trunk line to Amsterdam. It was then possible to exchange telephonic messages between Amsterdam and London, the arrangements for the trunk line transmission being made by the British and Dutch postal authorities. For the purposes of the wireless transmission a very short wave length was employed, with the object of eliminating atmospheric disturbances.

France and the Naval Agreement.

THE news that France, through her representatives at Washington, had demanded the right to build ten new capital ships of from 30,000 to 35,000 tons displacement during the next ten years threatened to put an end to the policy of standardising naval strength. It is good news, therefore, that this demand has been withdrawn, and that the relative proportion of naval strength in capital ships for Great Britain, the United States, Japan and France and Italy are likely to receive the assent of the five nations. It has been made clear, however, that these proportions are to apply to the actual fighting powers of the fleet rather than to mere numerical proportions in tonnage. To attain this end it has been agreed that Japan shall be allowed to retain the Mutsu, the newest of her big warships, that the United States shall retain two of her newer capital units, and that Great Britain shall be permitted to lay down two new ships of 35,000 tons. These vessels would replace the four ships for which the orders were recently withdrawn, and be the subject of new designs and new contracts. The submarine problem has still to be discussed, but it is regarded as doubtful whether the British proposal to abolish the submarine will be entertained by the other nations concerned. France is clearly hostile to this policy.

Fires on Shipboard.

AN interesting report dealing with fires on shipboard, for which Dr. J. T. Milton is responsible, has just been issued by Lloyd's Register of Shipping. This subject has attracted attention recently in consequence of one or two bunker fires, and the report issued by Lloyd's Register should be read in conjunction with one issued by the Board of Trade upon fires on British ships during the year ended July 31st, 1920. There were 242 such outbreaks, and an analysis of the situation in over 100 cases in which detailed information was available has been made by the Engineer-Surveyor-in-Chief to the Board of Trade. In 38 instances the fires were attributed to spontaneous combustion in cargoes of various commodities other than coal, and in 29 instances oil was the cause, mostly paraffin from lamps, or where paraffin was used as fuel for small motors. Only two cases were due to ordinary oil fuel carried by ocean-going vessels. There were 74 cases of fires in ships' bunkers, and about 50 per cent. of these fires are believed to have been due to spontaneous combustion. This cause of fire in bulk coal has been the subject of several investigations. The inquiry of the year 1912 led to the conclusion that all coal is liable to spontaneous combustion, and when ignition occurred on shipboard was probably due to fortuitous conditions in regard to the rate and supply of air and the rate of escape of the heat generated. Dr. Milton considers that recent experience confirms the conclusions then reached. Bunkers, it is advised, should be kept tight to prevent air passing through the coal and by being absorbed, causing overheating. Water, it is added, is the best medium for extinguishing coal fires.

An Electric Railway Within the Arctic Circle.

(Contributed.)

It is strange to contemplate that one can take a trip to the Arctic from London, and get there in four days by train, some small crossings by water being

FIG. 1—SWITCHGEAR HOUSE OVER PORJUS FALL POWER STATION

the only exceptions. But it is stranger still that at the end of the journey one finds industrial communities employing the latest types of modern machinery for traction, mining and the loading of ships. To cap it all, thanks to the munificence of the late Sir Ernest Cassel, an opera house is to be found in one of the mining communities. This very up-to-date part of the Arctic is the northern part of Sweden, and the cause of its state of advancement is the occurrence of enormous deposits of iron ore. These actual mountains of magnetic ore have been known for centuries, but they were inaccesible until modern improvements in railway construction brought them within reach. To begin with, a line was constructed between the town of Lulea, on the shore of the Gulf of Bothnia and the Gellivare mines, an enterprise in which a great deal of English money was sunk. The difficulties were, however, overcome, and the line was duly finished, and the mining and export of ore were begun. Still, it was felt that railway connection with an ice-free port on the Norwegian west coast was desirable. Hence the line was extended *vid* the Kiruna mines to Narwik and opened for traffic in 1902. Steam propulsion was adopted to begin with, but increasing prices of coal made the question of utilisation of the abundant water power of the district imperative. There was opposition to harnessing the waterfalls on account of their great natural beauty, but finally the interests of a few tourists, who generally get their money's worth, had to yield to the demands of an export of some 5,000,000 tons of iron ore annually. The cascades at Porjus were chosen as the first victims of the vandalism of progress, probably because another waterfall higher up on the same watercourse attracted more visitors. We are glad for their sake to be able to add that the latter has been permanently reserved as a beauty spot. The Porjus fall is a 1¼ mile long combination of rapids and falls which continue to the Gulf of Bothnia as the Great Lule River. At the point of junction the power station—Fig. 1—was erected in the years 1911 to 1914.

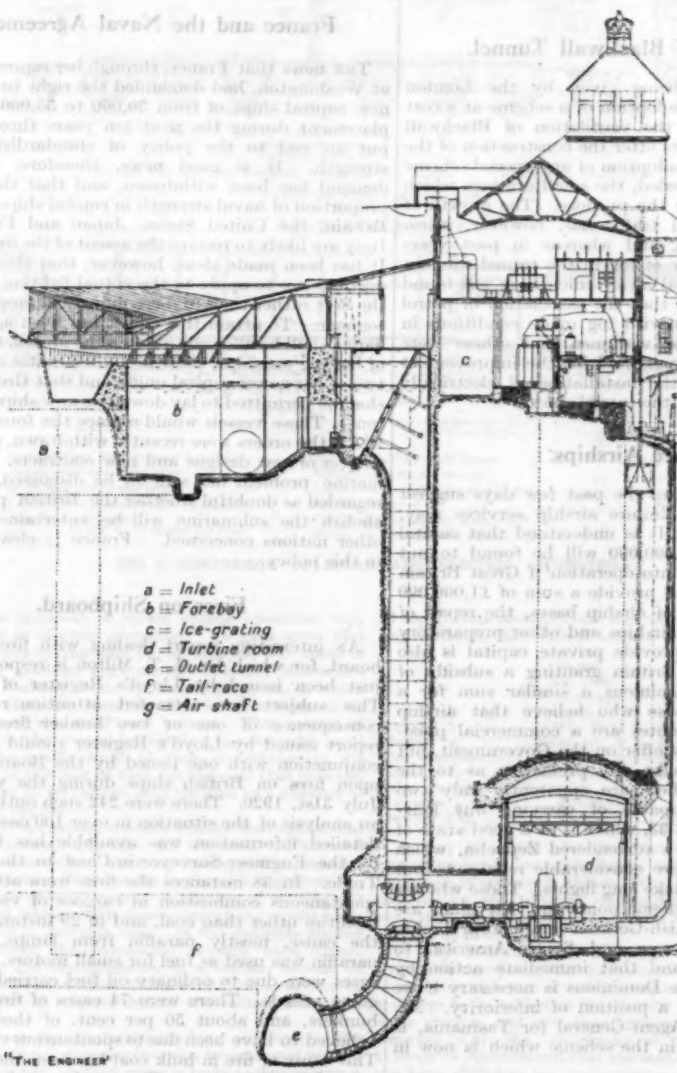


FIG. 2—SECTION THROUGH PORJUS FALL POWER STATION

By means of a dam and tunnels water is delivered to the power station with an available head of 50 m.; hence high-speed horizontal turbines are employed. The generating station itself is blasted out of the solid rock, and the generators are placed at the lower level, where the temperature stands at 50 deg. Fah. all the year round, although the mercury occasionally freezes above. The equipment was produced by the well-known Asea combine, and like most of their work, it bears the stamp of transplanted and, most probably, improved American practice. The power house, a section of which is given in Fig. 2, possesses a number of fairly familiar features. We regret that we have no illustrations of the connecting tunnels at our disposal, but their nature is easily imagined by analogy with American installations.

There are three sets of generators of 10,000 kilowatts each, two for single-phase only, and a third for both single and three-phase. On continuous load at 250 revolutions they can deliver 6250 kilowatts at 4000 volts and 15 cycles. Two machines are connected to one double water-cooled transformer in a building on the surface in such a way that the primaries are in parallel and the secondaries in series. Each step transforms up to 40,000 volts, so that the current is delivered to the line at 80,000 volts. All switches and control gear are arranged in the transformer building at the surface. The neutral points on the generators are earthed through a resistance of 8000 ohms; hence no short-circuit will occur by an accidental earthing of one of the high-tension lines, but merely a flow of 5 amperes to earth, which, as soon as it starts, gives warning at the station.

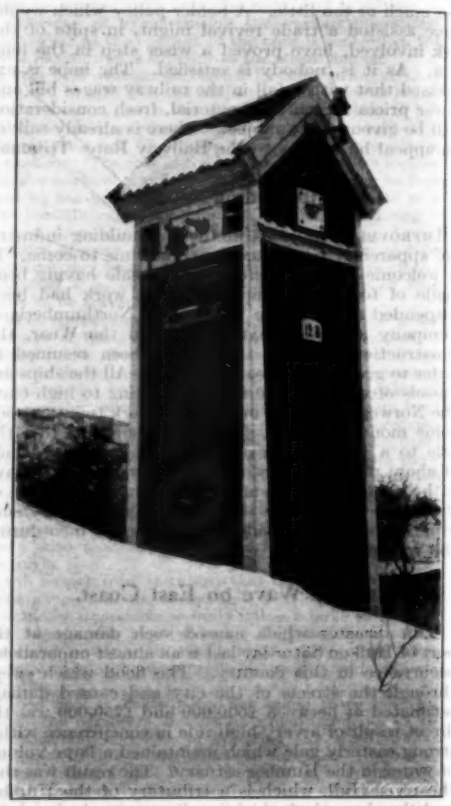


FIG. 3—LIGHTING TRANSFORMER HOUSE

For various reasons the transmission line—see Fig. 6 and the views on page 680—is composed of four conductors, two—one above the other—on each side of the supports, which are constructed of mild steel. On account of the climatic conditions, two kinds of transmission, for summer and winter respectively, are adopted. In summer, non-inductive transmission is used, *i.e.*, each side carries outgoing and returning current. In winter time, when hoar frost is common, each side carries current of the same potential to avoid bridging. On the line there are several control stations between the power-house and the first tapping point, Kirunavara, which lies not less than 120 kiloms. away. There are also transformer stations for lighting at various stopping places. The line is protected against lightning by means of ordinary "horn" lightning gaps at suitable intervals. For use on the line the current is transformed down to 16,000 volts, fed to a contact transmission system, consisting of a carrying cable of 50 square millimetre section, and a contact wire of 80 square millimetres. This wire has a section like the figure 8. It is supported 5.6 metres above the rails on open ground, but in tunnels and snow galleries it is as low as 4.56 m. The various switches on the system break the current in oil, and according to actual experiments the arc is extinguished in 0.2 sec. The length of the line from Kiuna to the frontier is some 200 kiloms.; hence we have in this case a transmission distance over 300 kiloms., or, say, 200 miles.

It is difficult for us here in England to realise the natural difficulties which had to be overcome in the building of this line. No railway in the world crosses such enormous stretches of marshland, and inclines of 1 in 100 are the rule in other parts. Furthermore, there is no agriculture, and food, as well as other supplies, have to be carried from the south. Then there is the darkness in winter to be contended with as well as Arctic fogs and snowstorms. As a private undertaking the thing could hardly have been done, as no earnings came in till the actual completion of the line. It speaks well for the Swedish Government that it has carried out the whole of the Northern railway system without sensibly increasing the burden of taxation, and that lavish waste of money was altogether avoided. There is no doubt that State undertakings have been an almost unbroken success in Sweden, whatever may be the case elsewhere. The natural bent of the people to prefer a somewhat meagre certainty to great expectations may have something to do with this. "The State's cake is small, but it is round," runs the Swedish proverb, and hence we see how a small people collectively carry out gigantic undertakings without the usual accompaniment of greed and robbery. This by the way.

The locomotives themselves carry transformers for reducing the voltage from 16,000 volts to 200 volts. The engines are composed of two short-coupled parts, each provided with separate driving bogies, transformers and motors. To protect the high-tension sides of the transformers there are automatic cut-outs, breaking the current in oil when it exceeds a fixed maximum. For regulating the voltage at the motor terminals, the first thirteen engines are provided with twenty contact points on the low-tension side of the transformers. The sliding contacts have a choking coil and treble contact blocks working three sections of the low-tension winding together, thus subdividing the breaking arcs. The motors are of the single-phase series-wound commutating type. They absorb 3000 to 5000 ampères at 200 volts. The field system is composed of twenty-four poles. The commutators have no less than 1140 segments. There are special windings in the magnet faces for damping out higher harmonics, as in every other part of the circuits. The total weight of these engines is 138 metric tons. By the adoption of motors of the commutating type, the advantages of both the alternating and direct-current systems are secured, *i.e.*, good starting torque and ease of regulation. These engines pull a load of 1855 metric tons at 30 kiloms. an hour up an incline of 1 in 100, and at 60 kiloms. on the level. For passenger trains the locomotives are smaller and faster but similar in all essentials. They pull 200 tons at 50 kiloms. on the inclines and at 100 kiloms. on the level. It is pleasant to note that the system has worked satisfactorily from the start after increasing the main bearings on the generators at the power-house. These bearings had been constructed to a formula which was all right for smaller machines, but failed in the case of these large units.

A difficulty arose with regard to the induction effect on the telegraph and telephone lines in the district. To find a remedy a commission was appointed to make experimental investigations. It issued a most comprehensive report, which was published by the Swedish Technological Society's publication department. We are indebted to this report on "Disturbances in Low-tension Lines by Single-phase Railways" for a number of details regarding the Porjus transmission. As an English translation is promised for the near future, we must defer discussing the main subject of that work for the present.

Having seen how the Polar regions of Northern Sweden are getting opened to commerce, we might ask ourselves whither all this development is leading. On closer study of what is going on just now, we find that the little-known place, Porjus, will very soon be the northern terminus of the Central Swedish Railway, which is almost completed, and which runs through the vast forests of Lapland. There is also a pig iron smelting works operated electrically from the power station, as well as blast-furnace plants at Lulea, and, of course, there are the enormous iron ore deposits. What interests us still more is that the Central Railway, on its way from the southern end at Ostensund to Porjus, crosses rivers, capable of yielding some 8,500,000 horse-power. A complete electrification of all the railways in the country is, judging from the experience with the most northerly one, only a matter of time. But this will simply be a beginning. Should coal prices keep at something like the present level permanently, then pig iron can be produced as cheaply in these high latitudes in the electric furnaces as here with coke.

FIG. 4—TRANSFORMER HOUSE

FIG. 5—SWITCH HOUSE

FIG. 6—TOWER ON TRANSMISSION LINE

We have seen how export facilities exist to the west, east and south. The forests could yield without depletion all the charcoal necessary for the reduction, and the water power remains, humanly speaking, constant. The manifestations of prices and export facilities of English coal, which up to the beginning of the war dominated the European market, have already had a permanent effect by bringing hydro-electric installations into being, wherever possible, and in Sweden and Denmark it has caused the building of ocean-going ships, driven by internal combustion engines for crude oil on an increasing scale. To replace the coal exports by manufactured goods also means lowering of coal prices. Such is the moral of a glimpse at what is going on elsewhere.

Algæ as Cause of Odours in Water.

TROUBLES with bad taste and smell in waters of lakes and reservoirs due to algæ or miscroscopical plant growth is a widespread experience in the United States, but the causes of the phenomena have not been clearly determined. The occurrence and extent vary from time to time, the trouble occurs mainly in the summer after prolonged heat, and it occurs more particularly where water is stagnant or sluggish and is relatively shallow. It is most troublesome when it affects water supply reservoirs, as it may be so bad for a time as to render the water very unpalatable and practically unusable. While the growth, smell and taste do not appear to affect the quality of the water, it is natural for the public to be suspicious and to attribute the condition to some dangerous pollution. Usually the smell and taste are of an oily or fishy character, sometimes with an acrid after-taste.

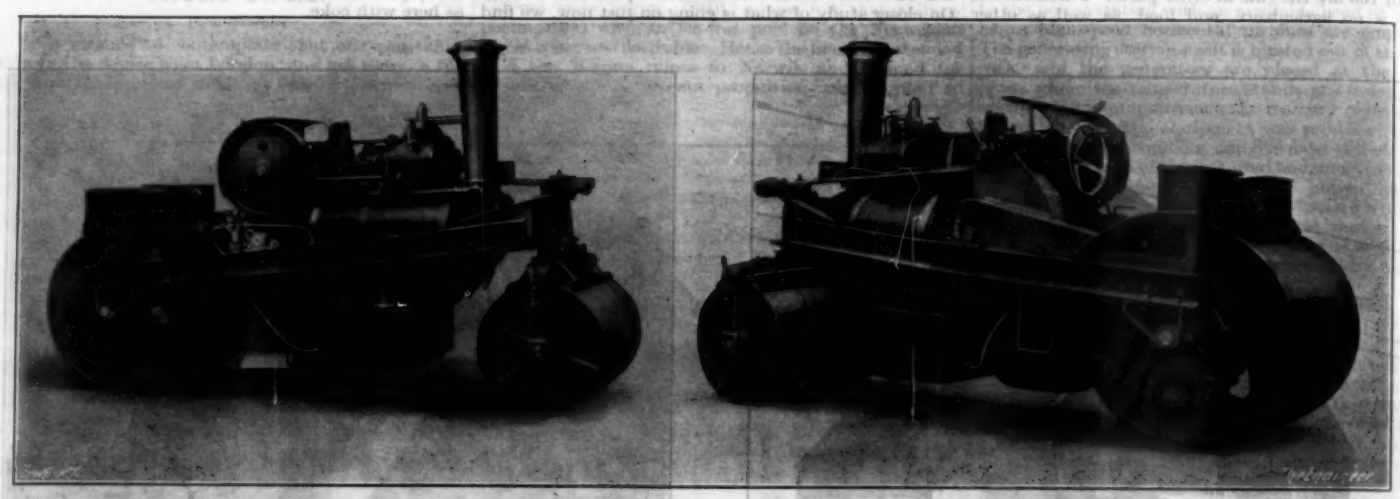
A rather special variant of this trouble has been a periodical experience at the city of Madison, in the United States, where Lake Monona, on which a part of the city is situated, gives off at times an overpowering and offensive odour that amounts to a stench and has been characterised as similar to that of a very foul and neglected pig pen. The water is not used for domestic supply, so that the principal consideration is the disgusting smell as a public nuisance. In 1918 the conditions were unusually bad, and public opinion attributed the cause to the city's sewage treatment works, it being assumed that either raw sewage was being admitted to the lake or that the filter effluent was of a very foul and improper character.

The city authorities in 1919 engaged Mr. John W. Alvord, an eminent consulting sanitary engineer, of Chicago, to investigate the matter. His report indicated that the sewage works were operating properly and efficiently, and were not responsible for the trouble. He was then directed to make further investigation in order to determine the cause and to suggest a remedy. His final report again absolved the sewage works, except as regarded a few minor contributory factors. He attributes the trouble to algal growths, to which the lake is peculiarly susceptible, and which at times—under favouring conditions—have an exceptionally great development.

Lake Monona is one of a chain of four lakes on the Yahara River, and a large portion of the city of Madison occupies a narrow strip of land between Lake Monona and Lake Mendota. Besides the natural drainage from within its watershed it receives a large part of the run-off from the storm-water sewers, the effluent from the city's sewage filtration plant, and a small amount of trade wastes. The aggregate of these three, however, is but a very

LIGHT WEIGHT TANDEM STEAM ROLLER

ROBEY AND CO., LIMITED, LINCOLN, ENGINEERS



small proportion of the flow of the river. In shape, Lake Monona is oblong, about 3 miles long and 1½ miles wide, and it has an area of 5½ square miles, with 14 miles of shore line, about 4 miles being along the built-up portion of the city. It has considerable shallow water around the shores, with a mean depth of 27½ft., and a maximum depth of 74ft. Its volume is approximately 4,200,000,000 cubic feet.

The water surface has an extreme variation of 2½ft., but is maintained normally at about 845ft. above sea level, the level being regulated to some extent by a lock and movable barrier in the reach of the river above the lake, or between lakes Monona and Mendota. The minimum summer flow into the lake is 50 cubic feet per second, but before winter sets in the lock gates are set open and the barrier is removed.

In the summer a zone of submerged aquatic weeds extends practically around the lake, from the shore out to about 10ft. of water, the weeds being mostly attached to the bottom, while at low water levels and late in the season they frequently extend to the surface, so as to offer lodgment for the accumulation of scums from algal growths. As in all fresh water lakes, the water contains a vast number of microscopic plant and animal organisms, known collectively as plankton, these forms of life feeding upon the living and dead organic matter in the water.

Most of the organisms are invisible to the naked eye, but some of the algæ are an exception. They often become quite evident in summer through the collection of large colonies of individuals which range from minute green specks suspended in the water to great collections of these colonies into floating masses forming "scum" or "bloom." The so-called blue-green algæ produce the offensive odours, especially during decay. The plankton as a whole is distributed very uniformly throughout the water, and averages 0.085 oz. to the cubic yard of water. The circulation in the lake is extremely slow, the regulated inflow and outflow being from 30 to 100 cubic feet per second, with an inflow velocity of about 1ft. per second. Wind is an important factor in the algæ problem, as its prevailing direction sweeps floating material upon the city portion of the shore, where the weeds and algæ decompose and give off offensive odours.

Definite history of the trouble is traced back to 1882, in which year Professor Trelease, of the University of Wisconsin, commenced observations, which he continued for several years. As early as June, 1882, the scum collected along the city shore in such quantity as to prevent boating, and the odour was noticeable at a considerable distance. Although changes of wind brought periods of relief, the condition continued at intervals until the end of November. He pointed out that as a rule protracted heat precedes the appearance of the scum, but this experience showed that a very short period of warmth may suffice for its production, as the spring of 1882 was cold. The *anabaena mendotae* and the larger varieties of *amboena* lasted until both the air and the water had become quite cold. It is to be noted that at that time the city had no sewers, so that sewage was not a factor. Furthermore, in the few years after the completion of the first sewerage system the algal growths were of small consequence.

Severely unpleasant conditions occurred again in 1898, in 1913, and in 1918, but almost every year there is more or less of a nuisance. In 1913 a resident on the shore brought an action for damages against the city, claiming that the offensive condition was caused by sewage pollution, but Mr. Langdon Pearce, a sanitary engineer engaged by the city, attributed it to decaying algæ. The repetition of these conditions in 1918 and the strong public opinion that sewage or the effluent from the city's sewage disposal plant—with Imhoff tanks, sedimentation basins and sprinkling filter—led the city authorities to call in Mr. Alvord. His exhaustive report shows conclusively that the sewage element is insignificant, and that the main and almost the sole cause is the growth of algæ and its subsequent death and decomposition. There is wide experience in the United States to prove that such offensive algal growth may occur in unpolluted water, as in the protected reservoirs for city water supply. The extent of the growth varies greatly from year to year, and the offensive conditions occur usually at intervals of a few years.

Referring again to the sewage, it is shown that the average relative stability of the final effluent is uniformly 95 per cent., which represents a high degree of effective purification by the sewage works and an effluent which is incapable of creating further nuisance by odours. The washings from a beet sugar factory, the storm water flows, and some small trade wastes are negligible as causes of the odours.

There are other conditions, however, in which the sewage effluent might possibly assist the production of the trouble, and that is by furnishing plant food. Here, again, however, Mr. Alvord shows that the influence is very slight, and that the form of plant food thus furnished is not necessary to the development of growth on a large scale, as evidenced by such development in unpolluted waters. The impression that nitrates are a direct measure of plant or algal growth is not borne out by the Madison investigation.

It must be explained that the physiology of fresh-water algæ is not well understood. While it is recognised that nitrates which the treated sewage effluent introduces into Lake Monona in considerable quantity is an indispensable food for plant life, it has been proved elsewhere that relatively small amounts of nitrate (as where there is no pollution) are sufficient to support luxurious growths of aquatic plant life. It has been shown experimentally and by extensive observation that some other factor than the inorganic food supply determines the extent to which algæ and similar growths will flourish. Mr. Alvord says it is not known what this factor is, but there is some evidence that it is an organic substance, and may be a waste product of certain organic life of the complex environment in which the algæ grow.

Remedy by prevention instead of cure is included in the recommendations of Mr. Alvord's report, this remedy consisting of the copper sulphate treatment which has been used in a number of lakes and reservoirs in the United States for the destruction of obnoxious weed and plant growth. An attempt at this treatment was made in 1918, when conditions of algæ growth and odour were very severe. About four tons of the chemical were used, being applied by towing it in sacks from a launch at the points of greatest trouble. This was locally effective, but any general improvement was impossible because the entire lake was covered with algæ decomposition, against which no headway could be made. In 1919 about five tons were used in the same way, but the lake was unusually clear and free from algæ growth during that season and no marked nuisance had occurred.

Although Lake Monona is larger than any other body of water that has been controlled by the use of copper sulphate, it is believed that it can be controlled by means of that chemical to a large extent, if not completely. This can only be accomplished, however, by unusual care in scientific supervision and by laboratory tests which will show in advance where algæ are forming, and when and where the treatment must be applied to prevent rather than to cure the evil. It is recommended, therefore, that during the summer months a suitable biological laboratory should be provided at some convenient point, samples of lake growths during summer and autumn being kept under constant supervision and analysis. When early symptoms of algal growth are observed, particularly in abnormal amounts, the copper sulphate would be applied in location and quantity as directed by the biologist in charge, in order to prevent the further growth of the algæ, and in this way prevent the death and decay which would result in an eruptive outbreak of the offensive stench. The cost of plant and control would be about £1000 per annum. As the University of Wisconsin is situated at Madison it should be easy to secure the co-operation and assistance of its biological department.

Tandem Steam Road Roller.

In the account of the Public Works, Roads and Transport Exhibition, which appeared in our issue of November 25th, we briefly mentioned that Robey and Co., Limited, of Lincoln, were exhibiting a lightweight tandem steam roller possessing some novel features. We are now enabled to illustrate the machine in the accompanying engravings. The machine is interesting in several respects, and not least on account of the frame work which, as will be observed, is of quite unusual design. Furthermore, the engine, boiler, &c., are identical with those which the firm uses for its steam wagon and which are standardised. The boiler is of the locomotive type with a round fire-box riveted to it, but there are no stays. It is furnished with forty-one tubes 1¾in. in diameter and the total heating surface is 78.17 square feet, the grate area being 3.14 square feet. The engine, which is mounted on the top of the boiler, is of the horizontal compound type, with cylinders 4in. and 7¼in. in diameter arranged side by side and having a stroke of 7in. The valves are of the piston type. With a boiler pressure of 200 lb. per square inch and at a speed of 430 revolutions per minute the horse-power developed is given as being 25. The engine speed is reduced by gearing, the final drive on to the rear axle being by roller chain. The travelling speed is 4 miles per hour.

The roller is made in two sizes, which weigh 5 and 6 tons respectively. The driven roller wheels are 3ft. 7¼in. in diameter and 3ft. 8in. wide. The steering wheels are of the same width, but only 2ft. 6in. in diameter. The rims of the hind wheels are renewable, being only bolted to the spokes. As the wheels are arranged tandem, the total width rolled is, of course, also 3ft. 8in. The steering is effected by means of a hand wheel arranged in front of the driver and operating through a worm and quadrant. The capacity of the water tank is 40 gallons, and two methods of feeding the boiler are provided, one being by means of a force pump which can be worked while the roller is standing, and the other by means of an injector. The overall length of the roller is 12ft. 9in.

SCHOLARSHIPS IN ENGINEERING.

The British Electrical and Allied Manufacturers' Association (Incorporated) has, on the recommendation of its Education Committee, recently granted the following scholarships, each tenable for one year and each carrying a maintenance allowance of £100 and the payment of college fees:—

IN ELECTRICAL ENGINEERING (STEAM TURBO-GENERATORS).

Leonard Hulford Lodge Badham. Tenable at the City and Guilds (Engineering) College, South Kensington.

Mr. Badham received his education at Rugby Technical Schools. He served in the Royal Engineers.

John Henry Butcher. Tenable at the City and Guilds (Engineering) College, South Kensington.

Mr. Butcher received his education at Rugby Lower School of Lawrence Sheriffe and Finsbury Technical College.

James Ernest Macfarlane. Tenable at Brighton Technical College.

Mr. Macfarlane received his education at Brighton Technical College, where he held a scholarship. He served in the Royal Navy from August, 1914, to February, 1919.

IN MECHANICAL ENGINEERING (STEAM TURBINES).

William Stanley Bowers. Tenable at Finsbury Technical College.

Mr. Bowers received his education at Erith Technical Institute, where he held a scholarship.

John Arthur Snape. Tenable at Manchester College of Technology.

Mr. Snape received his education at Manchester College of Technology (Associate). He served in the Royal Air Force.

Morris Lord Yates. Tenable at Manchester College of Technology.

Mr. Yates received his education at Rugby Lower School of Lawrence Sheriffe and Rugby Technical Schools.

Speaking at the annual general meeting of Dorman, Long and Co., Limited, on the 13th instant, Sir Hugh Bell said: "In the case of export the cost of placing 1 ton of steel on board ship has risen from 2s. 3d. to 6s. This is an unfair handicap, and we look to the railway companies to help us and to bring their rates to a figure which will compare more favourably with the fall in prices which has taken place in every other direction. The point I wish to emphasise is that whereas all other classes of labour have suffered heavy reduction in wages and while employers are working with little or no profit, railway rates remain at a figure which, if maintained, must ultimately cause a complete stoppage in the iron and steel trade. It makes it all the more aggravating to hear of English railway companies who possess a monopoly of our carrying trade placing orders for rails on the Continent on account of a difference in price which would be negligible had they adapted themselves to present-day conditions."

Railway Matters.

IT is an interesting sign of the times that both the London and North-Western and Great Western companies are running excursions to Ireland for Christmas—the first for seven years.

AT the adjourned inquest on Tuesday last on the two men and a little girl killed in the collision of November 26th between two Midland trains at Birmingham (New-street) the jury returned a verdict of "Accidental death."

WHILST, as stated in this column on December 9th, the Midland Railway workshops at Derby will be closed for a full week at Christmas, it should be added that they are working full time, instead of on four days only, for the two weeks previous to Christmas.

THE English and Welsh railway companies are reducing, as from January 1st, the increase of 100 per cent. in the base rates for coal, coke, limestone for chemical works, lime for iron and steel working and for iron and steel to 75 per cent., and the present flat rate of 6d. per ton to 4d. per ton.

THE rapid completion of the projected City—tube—railway in Sydney is being urged in view of the great increase in passenger traffic on the southern side of the harbour. The estimated cost of the work in 1914 was £3,000,000, but to-day the cost would, it is calculated, probably amount to £6,500,000.

OUR American contemporary, the *Railway Age*, points out that it is frequently possible to effect economies through the application of automatically controlled, electrically driven machinery to air compressors, coal shoots, pumping stations and isolated plants. This statement prompts us to say that in this country outlying pumping engines are often controlled from railway stations some distance away.

IT is announced that the Minister of Transport, on the nomination of the Board of Trade, has appointed Mr. G. C. Locket to be a member of the Rates Advisory Committee in place of Mr. L. A. Martin, who has resigned. Mr. Martin was the representative of trade on the Committee. It will be remembered that, as announced in this column on the 11th ultimo, Mr. Locket is the commercial member of the Railway Rates Tribunal.

IN June last the cost of living figure was 119 per cent above that of July, 1914. As in September it was 120 per cent., the change was not sufficient for any alteration in the railwaymen's wages when they underwent the quarterly review. The percentage increase is now 99, a drop of 20 points, so that the railwaymen will have to suffer a reduction of 4s. per week—one shilling for every five points—from January 1st. The matter comes before the Central Wages Board to-day (Friday).

THE Railway Finance Committee, which is sitting in Calcutta, has issued a unanimous report advising no separation of railway finance from the general finance of the Indian Government. Owing, however, to the general condition of the Indian railways, the Committee recommends an annual expenditure of thirty crores of rupees for the next five years without lapses for the rehabilitation of the lines. This will involve supplementing the Indian Rupee Loan by borrowing in foreign markets on the easiest terms possible.

DURING the perishable fruit season of 1921 the Nashville, Chattanooga and St. Louis Railroad moved north from Atlanta 10,000 cars of fruit and vegetables. They included 4800 cars of water melons, 2000 of pineapples, 1400 of fresh vegetables, 25 of cantaloupes, and 1800 of citrous fruits. The conveyance of the pineapples needs special mention. Sixty-one trains carried nothing else but pine-apples, and each train had an average of 20 cars. From Atlanta to Martin, the junction with the Illinois Central, the distance is 430 miles, within which are three termini, and all but 40 miles is single-tracked. This distance was covered in an average of 23 hours.

THE scheme for the amalgamation of the London and North-Western and Lancashire and Yorkshire Railway companies came before the Railway Amalgamation Tribunal for approval on Tuesday last. The Railway Companies' Association opposed a section in the scheme which would allow the amalgamated companies, without further or other authority, to raise capital for absorbing other companies under Section 8 of the Railways Act. The Tribunal decided that this section was not a necessary part of the scheme, and ordered its withdrawal. The scheme was then formally approved. Many changes are being made in the higher officers of the two companies, to which we hope to refer when the list is confirmed.

SPEAKING on Sir George Paish's paper, "The Future of British Railways" at the Institute of Transport on the 12th instant, Sir Henry Thornton, general manager of the Great Eastern Railway, said that English railway companies had, in the past, lived in an atmosphere of cheap labour. Labour had now, however, become expensive, and attention must be turned to automatic signals, to mechanical coal and ash-handling plant, to electrification, and all those devices which would enable the railways to employ a smaller number of men at a higher rate of pay with an increased output. It was exceedingly difficult to get the average railway manager or director to turn a somersault and to reverse, within a short space of time, a policy which he and his predecessors had followed so long.

THE Railway Amalgamation Tribunal met on the 13th instant to consider the proposed allocation of the 24½ millions sanctioned under Section 11 of the Railways Act. The London and North-Western heads the list with £3,187,814, followed by £2,999,566 for the Great Western, £2,929,291 for the Midland, and £2,375,333 for the North-Eastern. Colonel H. F. Stephens opposed on behalf of the Kent and East Sussex, the Shropshire and Montgomery and the Weston, Clevedon and Portishead, on the ground that they had been under control and their property had been made use of for seven or eight years and the compensation was not sufficient. Colonel Stephens subsequently said that he would not object to the scheme of distribution, but reserved the right to make another claim. The Tribunal then approved the scheme.

Notes and Memoranda.

IN an appendix to a paper on Works Plant, read before the Association of Engineering and Shipbuilding Draughtsmen by Mr. R. M. Robertson, there are some excellent tables giving the power required to drive modern machines. The tables are extensive, and cover practically every class of metal-working machines.

THE Paris *Matin* recently reported that by a new process introduced lately at the Heinitz coke works, which belong to the French domaine mines in the autonomous Sarre territory, a hard and resistant metallurgical coke has been obtained from entirely unmixed Sarre coal. The new system is the discovery of a Paris chemist, Monsieur William Boulin, who has worked at the Sarre mines since December, 1919.

RECENT investigations in connection with iron ore deposits on the island of Jussaroe, in the Gulf of Finland, are said to have shown that the deposits, which cover a large area, contain up to 40 per cent. of iron ore. The ore is of the best quality, similar to that of Norwegian and Swedish ore, and the deposits are of considerable thickness, measuring in some places up to 18 m. or 20 m. Steps are being taken for the exploitation of the deposits which, it is anticipated, will not only supply home consumption, but also render possible the export of iron.

WHAT is described as being a cheap and effective process for the extraction of oil is now being applied to some of the shale deposits which Australia possesses in large quantities. At Joadja and Reedy Creek, near Millagong, New South Wales, the Oil Shale Products and Coal Company, Limited, after two years' experimenting, is using a dry distillation process, from which a return of 100 gallons of crude oil to the ton is being obtained. The field of operation of the firm is about 90 miles from Sydney, and consists of 6000 acres with a practically unlimited supply of shale. The quality of the oil is said to be excellent, giving better test results than any imported oils.

ACCORDING to French trade returns just issued, the imports into France during the first eleven months of 1921 amounted in value to 20,394 million francs and in weight to 32,776,570 metric tons, as compared with 45,176,529 metric tons in 1920 and 39,970,544 in 1913. The weight of the raw materials was 28,000,000 tons, as compared with 37,000,000 in 1920 and of the manufactured goods 1,283,245 metric tons, as compared with 2,268,404 in 1920. The exports are valued at 19,370 million francs, and their weight was 13,493,951 metric tons, as compared with 11,687,538 in 1920 and 20,027,466 metric tons in 1913. The increase as compared with last year was due to the export of an additional 2,000,000 tons of raw materials.

THE importance of adequate ventilation of the double bottoms of ships has not yet been generally realised, according to Mr. J. L. Adam, who read a paper on the subject before the Institution of Engineers and Shipbuilders in Scotland. If 6in. diameter ventilators were fitted at the corners of each tank in place of the usual 2½in. pipe, such obstruction in the cargo space and extra cost as may be involved are negligible, he said, in comparison with the prolongation of the lifetime of the steel work in the tank. It is becoming more common practice to fit larger air pipes in double bottoms, probably because the tanks are used for the carriage of oil fuel, and this step in the right direction should be followed until proper ventilation becomes every-day practice.

THE production of pig iron in November, according to the National Federation of Iron and Steel Manufacturers, showed a further slight rise to 271,800 tons (compared with 235,500 tons in October), but is still much below the production immediately before the coal stoppage, and less than 40 per cent. of the production in the autumn of 1920. Only 85 furnaces were in blast at the end of the month compared with 82 at the beginning of the month, 2 having suspended and 5 resumed operations during the month. Before the stoppage 109 furnaces were in blast and in the autumn of last year over 300. Of the pig iron produced, 90,300 tons were hematite, 80,500 tons basic, 79,100 tons foundry and 15,000 tons forge. The production of steel in November amounted to 442,800 tons, the highest output attained since February, but only 50 per cent. of the production of September, 1920.

COMMENTING on a report concerning the condition of the suspension cables of the great New York bridges, the *Engineering News Record* says:—"As we look at the ancient stone bridges of Europe, we reflect with wonder and admiration on their endurance through the ages; yet it is not beyond the bounds of possibility that our great steel bridges may survive as long. Quite generally the world has been content to look upon iron and steel bridges as short-lived—built to-day and rusted out to-morrow. But with the proof from experience that carefully maintained structures are by no means perishable, but continue in service with no noticeable deterioration, these views need to be recast, and bridges come to be looked upon as enduring works, whose planning merits the same scrupulous consideration of long-time needs as does that of harbours or power developments."

THE American General Electric Company has recently patented a process for preventing the surface oxidation of metals or alloys exposed to high temperatures. The metal or alloy, placed in a retort filled with fine aluminium powder, is brought to a red heat. It is stated that metal treated in this manner will stand a temperature of 900 deg. Cent. for an indefinite period, whereas untreated surfaces will oxidise at about 600 deg. Cent. The aluminium will penetrate the surface of the metal to any desired depth. The result of exposure at high temperatures after this treatment is that the surface becomes coated with a layer of aluminium oxide. The process is said to make copper, brass, and nickel impervious to certain acids, and iron, steel, copper, and brass are among the metals and alloys which have been successfully treated. Rolled, wrought, drawn, or pressed metals lend themselves better to this process than cast material, while any necessary work, such as planing, hammering, or riveting, must be done before treating in order to preserve the oxide layer. Welding of the treated material is not possible.

Miscellanea.

GLASGOW merchants are considering a proposal for a Scottish trade exhibition in Amsterdam next year.

A MOTOR service is to be organised between Hangchow and Yuhang, China, at a cost of some £30,000. Eight cars for passengers and four goods lorries are to be used.

THE Tata Iron and Steel Company is opening a metallurgical school at Jamshedpur, with the object of training young men to take the place of imported labour in the blast and steel furnaces.

THE first steel foundry to be worked in Ireland recently started operations in Belfast. It is equipped with a 1½-ton two-phase electric furnace which takes about 800 k.V.A from the Corporation mains.

A NEW light alloy, described in the *Zeitschrift des Vereines deutscher Ingenieure*, contains 14 per cent. silicon and the remainder is aluminium. It has a specific gravity of 2.5–2.65. The tensile strength is 12.7 tons per square inch, while the elongation, 5–10 per cent., is double that of the common alloys. The tensile strength decreases slowly with rise in temperature.

THE Indian Institute of Engineers has entered upon its second year, and is expected to become a very powerful body, contributing greatly to engineering progress in that country. The Institute has local branches in Bengal, Bombay, Madras and the United Provinces, while branches in the native states, such as Mysore, will soon begin their activities. The membership is, we understand, increasing rapidly.

THE last few years have witnessed an increasing exploitation of the tungsten ores in Kiangsi, China. The annual yield has reached over 1000 tons of a value of from 400,000 to 500,000 dollars. Tin is also receiving much attention in the province. It is mostly found in the river basins in the districts of Nanking and Chungyi. The annual output is estimated at about 100 tons, of a value of 100,000 dollars.

AN earth dam, which, it is said, will be the highest ever made, is being constructed by the United States Reclamation Service on the Tieton River, in Washington. It will be 232ft. high by 900ft. long at the top, with a reinforced concrete core wall. The core is being sunk 100ft. below the river bed by sinking shafts to the full depth and tunnelling along the dam. The tunnel is extended upwards by a stoping process and filled with concrete as the work progresses. In this way the expense of timbering an open trench is avoided.

IN order to stimulate interest in saving labour in the home, the Women's Engineering Society has decided to hold a competition which will give women an opportunity of bringing forward some of the improvements which they consider necessary to the more efficient working of the home. This competition will not be confined to members of the Women's Engineering Society, but will be open to all women. One of the chief points upon which the entries to the competition will be judged will be the economy with which the idea could be carried out.

OF the loan that was raised about two years ago by the town of Paris for the carrying out of a vast scheme of improvements, a sum of 225 million francs is to be devoted to works which will be started upon in 1922. The repairing and renovation of public buildings which have been neglected since 1914 will absorb only a small part of this sum, but 17,000,000f. will be spent upon dwelling-houses for the working classes, and 25,000,000f. are reserved for bringing to Paris a daily supply of 80,000 cubic metres of water from the sources of the Durteint and Dragon rivers.

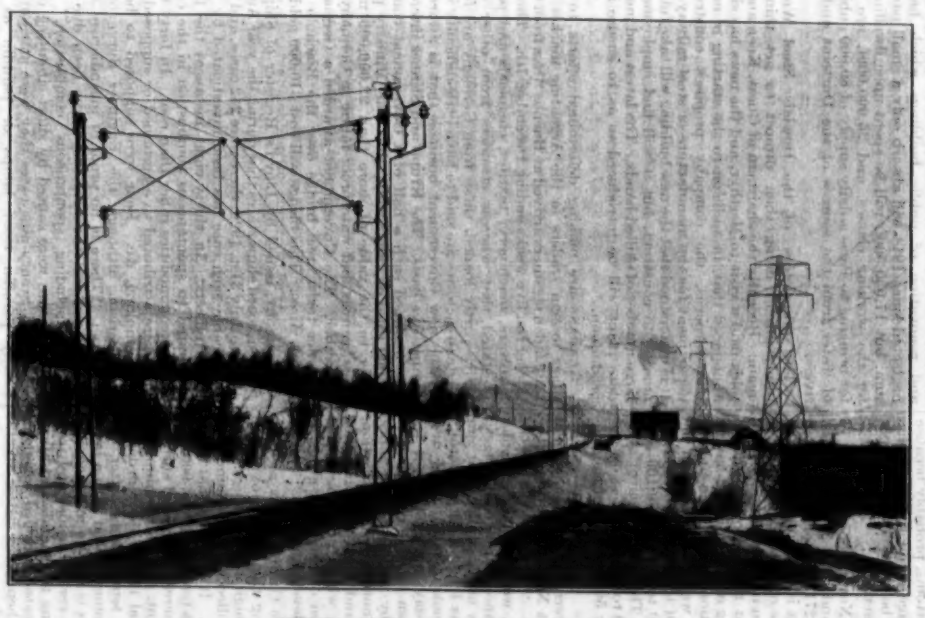
THE proprietors of the Dowlais Steel Works certainly intend doing their utmost to get things going again. Recently the chairman of Guest, Keen and Nettlefolds paid a visit to Merthyr, and the news has since been announced that, in addition to the starting of one of the blast-furnaces, the company proposes constructing a department for the manufacture of steel railway sleepers. It is understood that the new building will take fully twelve months to construct, but it will find employment for a large number of skilled hands. The latest and most up-to-date plant will be introduced so as to ensure intensive production.

GERMANS are making determined efforts to displace other foreign traders in the Argentine market. Eleven fully laden steamers arrived at Buenos Aires from Germany during the five weeks ending December 7th. They carried hardware, machinery, textiles, chemicals and paper. It is stated that whereas steamers from other countries arrive partly loaded, those from Germany are full. The German factories are said to have little difficulty in getting all the new Government business that is awarded on a competitive basis. The Krupp and Stinnes interests have just obtained each a half of a Government contract for 40,000 tons of rails, while the War Ministry placed an order to the value of more than 22,000,000 marks for tents, canvas and waterproof fabric in Germany early in December. The Government awarded a German firm a contract for a steel bridge over the Riacholo River at Buenos Aires. This bridge will cost 310,000 gold pesos.

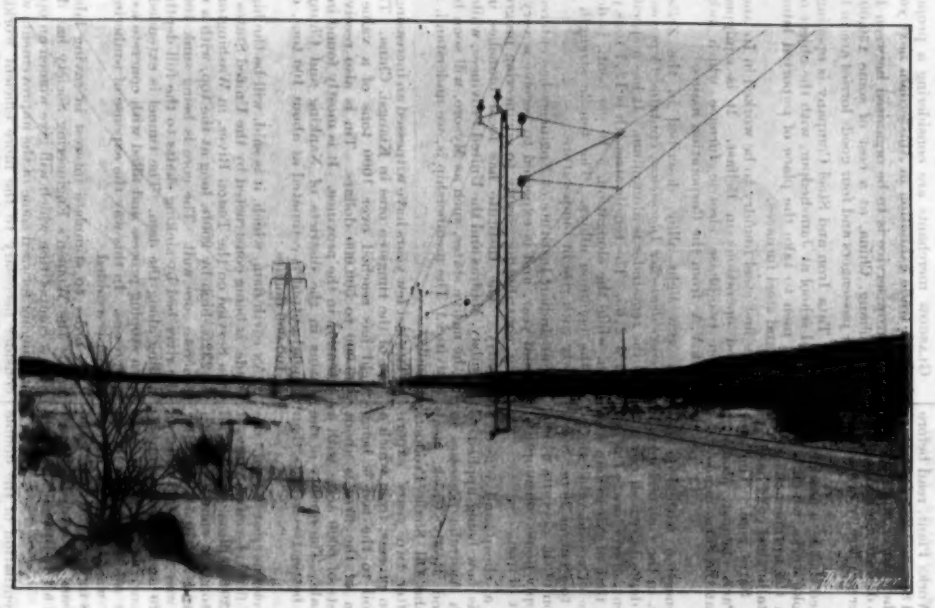
A REPORT, issued by Lloyd's Register of Shipping, on fires on board ships states that during the year August 1st, 1919, to July 31st, 1920, there were 242 cases, and wherever practicable each case has been investigated by Board of Trade officers. In thirty-eight instances the fires were attributed to spontaneous combustion in the cargoes of various commodities other than coal. In forty-two cases they were attributed to ascertained or supposed carelessness, smoking, &c. Four were supposed to be due to incendiarism, although the Engineer Surveyor-in-Chief remarks: "There is no proof of incendiarism in any of these cases, and the fires may have been due to other causes, including spontaneous combustion." In six cases the fires were caused by short-circuiting of electric wires. In twenty-nine cases they were attributed to oil, mostly paraffin from lamps or paraffin as used for fuel for small motors, only two cases being due to ordinary oil fuel in ocean-going vessels. In one of these latter the primary cause was a leaky pipe joint, and in the other a defective oil burner valve.

THE ELECTRIC RAILWAY BETWEEN LULEA AND NARWICK IN SWEDEN

(For description see page 676)



FEEDING POINT IN OVERHEAD EQUIPMENT



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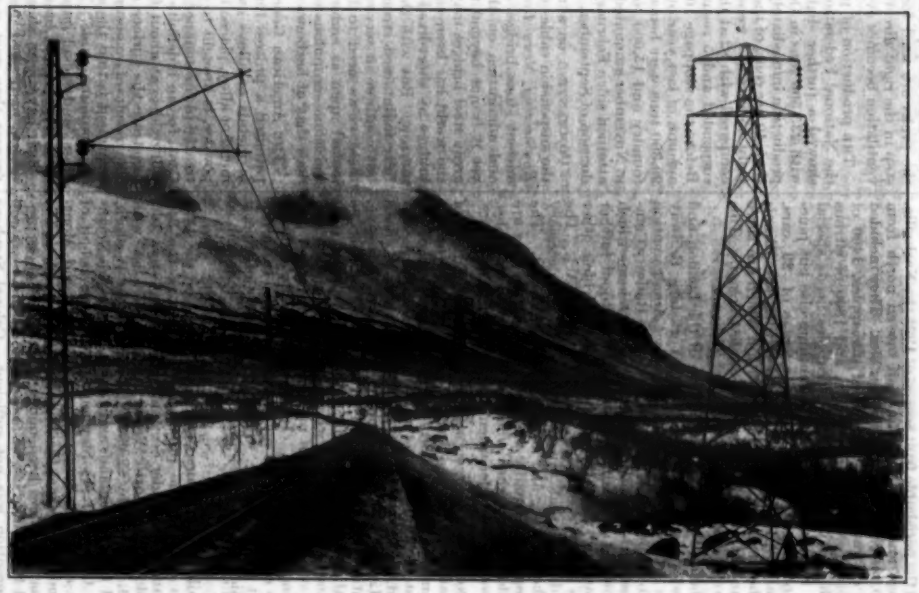

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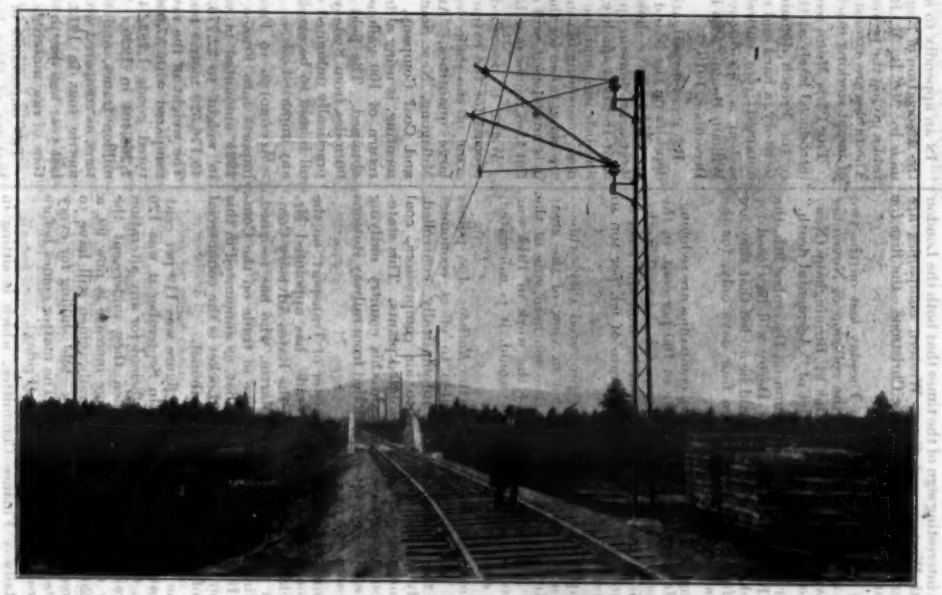

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THE ENGINEER.

DECEMBER 23, 1921.

Gear-boxes.

A PLEASANT feature of the meeting of the Institution of Automobile Engineers last week, when Mr. H. F. L. Orcutt presented an admirable paper on gear-boxes, was the good part in which the members took what was, in fact, a sound trouncing. Almost in his first words the author told them that "An experience extending over about ten years of dealing with all sorts of gear-boxes, from those in the "light car" to the 6-ton lorry, justifies the statement that, generally speaking, gear-boxes are not well designed, and are badly made." He then entered into particulars beginning with the gear-box itself, which he condemned as insufficiently rigid for the loads passing through it. From the box he passed to the shafts which he found too small, and from them was led to the bearings, which he held to be generally insufficient in number and badly placed. "In practice," he said, "with but rare exceptions, gears taking the heaviest loads are in the middle of the shafts and as far removed from the bearings as they can be." On the question of the gear wheels themselves he accused motor car makers of "a lack of understanding of the extreme accuracy in gear tooth forms that is necessary for quiet running, and the natural corollary that a badly mounted gear with perfect teeth cannot run with good contact. Designers and producers do not usually co-operate in taking every possible precaution that gears run dead true under load." Turning to workmanship, he asserted that "Too little attention is given to accurate machine operations, and too much is left for the fitter, the assembler, and the tester, while limits of errors and clearances are not properly fixed, and inspection is not well organised." And again, "in respect to workmanship it must be admitted that bad workmanship is the rule and not the exception. . . . How many gear-box makers know exactly what they have done to a defective box which finally passes the test? Gears distorted by heat treatment are 'run in.' Often the teeth are 'stoned.' Boxes are mounted in the chassis and given a road test, condemned, dismounted, and gears perhaps 'stoned' again or scrapped and replaced. Finally the box passes test. Who can say what has been done to cure the evils or exactly what was the original error? . . . Uncertain costs are tolerated, and quiet running on *all* speeds is usually given up as a hopeless task." From these passages from Mr. Orcutt's indictment it will, we think, be agreed that he struck out fairly from the shoulder and that an Institution which could take such punishment without flinching exhibits remarkable signs of grace. But whilst the author was, as we have seen, extremely critical—critical with the experience of a man who knew what was right and how it could be attained—he was also constructive, and made many valuable suggestions as to the means of improving gears.

It was a noteworthy fact that not once in the paper did Mr. Orcutt refer to the running efficiency of gears. That may seem strange until we consider what a very small effect an improvement in the efficiency of the gears has upon the petrol consumption. Take as a simple example a car driven 5000 miles per year. Improving the efficiency of the gear-box by 5 per cent., say, from 85 to 90 per cent., may mean an overall increase in efficiency of 3 per cent., and 3 per cent. added to 5000 miles is only 150 miles, or the equivalent of less than 10 gallons of petrol per annum. Quite obviously, then, it is a matter hardly worth troubling about. Of course, an inefficient gear-box may be costly in other directions. Its upkeep may be excessive, and it may use far too much oil and it may be very noisy. But it has not *of necessity* these defects. For instance, the reduction in friction that is effected by using ball or roller bearings may not in itself be worth while. A plain bearing runs more quietly than a ball bearing, and on that account it might be profitable to sacrifice some of the gain in mechanical efficiency. Again, hydraulic gears are not so efficient as mechanical gears, but they have certain compensating advantages. Shortly, the sacrifice of a few per cent. of mechanical efficiency in the gear-box may be profitable, and in any case is not to be feared, provided always that it is not accompanied by a greater susceptibility to wear and other troubles. It was such considerations as these, no doubt, which led Mr. Orcutt to adopt as his measure, if we may so call it, of efficiency that immeasurable quantity which we call noise. Noise is indeed the worst remaining defect of gear-boxes, but how far it is attributable to the gears themselves and how far to the environment of the gears it is impossible to say. Wheels that will run in perfect silence in the open become noisy in the box, worse in the car, and intolerable on the road. Absence of noise as a measure of the excellence of tooth shape and accuracy of mesh has its value, great value, but it is not sufficient to think of it alone. The car as a whole must be considered. It is here that we find one of the best aspects of Mr. Orcutt's paper. He does not, as so many have done, look at the gears alone; he looks at the whole gear-box and endeavours to track noise down not only to its origin but to the causes of its magnification. We trust someone else will go still further. We trust the Institution of Automobile Engineers will pursue this problem of the noisy car from the gears right through every part. It would be a fascinating subject for an exhaustive research, and we should like to suggest its adoption by the Institution. It may be difficult to measure noise quantitatively, but at any rate it is easy to recognise its absence and the lack of a noise meter to which we recently referred need be no obstacle to the pursuit of silence.

After all is said and done about gear-boxes; after we have improved them in every way and made them humanly perfect, they still remain an interloper between the engine and its job. The great object of the motor car engineer should be to improve them out of existence. Think of the millions of hours of labour that are expended on making gears and their boxes, the capital that has to be invested in special plant for their production, the workshop space that has to be given up to their manufacture! And all the time, as we have said, they are interloping between the engine and its business of driving the vehicle. Motor car engineers have grown up with gears and do not see what objectionable things they are. The more the gears are improved the less and less do the objections appear; but they are still there, and we would urge designers to think as little as may be necessary of their improvement, and as much as possible of their total deletion. Engine flexibility has been vastly improved, and cars will take hills on "top" which they would not have looked at a few years ago. It is in that direction that we must work. We must resist all temptation to look upon the petrol engine as in its final form, and we must constantly remind ourselves that however perfect the gear-box may be, it is still a very objectionable—possibly the most objectionable feature—of the motor car.

Boiler Explosions.

THERE was a time when mystery was allowed to enwrap the bursting of boilers. If one failed and an obvious cause was not at once discovered—and from the nature of things the evidence of cause is frequently destroyed by the accident itself—someone always endeavoured to prove, frequently with ingenious arguments and experiments, that some strange and rather obscure phenomenon had acted. Sometimes it was the water in the boiler that was presumed to have behaved in a strange and rare manner; at others, the material of the shell or the fire-box was held to have exhibited deceitful pro-

perties of one kind or another. It is not surprising that in the state of knowledge that prevailed in the days of which we speak such views should have been entertained, especially with regard to the materials of which boilers were made. The science of metallurgy hardly existed; Fairbairn had not entered upon that series of experiments with which his name will always be associated; the microscopy of metals was entirely unknown, and the value of heat treatment was as little suspected as the influence of cold and hot working was appreciated. Looking back to the 'fifties and 'sixties of last century, and even to later years in the light of our present knowledge, it is rather a matter of surprise that boiler explosions were not more numerous than they actually were than that they did occur at fairly frequent intervals, for to the absence of knowledge on the part of engineers and metallurgists we must add the still greater ignorance of the firemen to whose hands boilers were entrusted and the indifferent quality of the fittings with which boilers were supplied.

The age of mystery in boiler explosions has fortunately passed for ever. It is probable that many of the younger generation of engineers have never even heard of the causes that were seriously discussed by their fathers. One of these was the spheroidal condition of water, which was frequently invoked even up to the eighties of the last century to account for the violence of some explosions. The substance of this theory was that a mass of water might reach a condition of retarded ebullition by entering into the spheroidal state. That state is exhibited when a drop of water falls upon a hot plate. The drop does not immediately evaporate, but retains a more or less globular shape and spins about whilst emitting steam from its surface. In 1905, the Manchester Steam Users' Association celebrated its jubilee, and in an account of the fifty years of its activities we find the following passage: "The terror of the philosophical myth about the harmful power of the spheroidal condition of water overshadowed all other and far more real dangers. Drops of water poured on to a red-hot plate had been seen to shoot about for a time and then burst into steam. Nobody had taken the trouble to measure the temperature of these drops, but it was believed that they stored an enormous amount of energy, and by arguments, unsupported by experiments, it was thought to have been proved that the whole volume of water in a boiler was frequently in a spheroidal condition and required but the least impulse to burst into steam and cause an explosion. One of the most certain causes to produce such a disaster was believed to be the introduction of cold water into the boiler, a myth which persisted even after this Association had carried out its costly experiments on red-hot furnaces; it was advanced by some journals, including even the *Lancet*, so late as 1894." We should not like to say that it is quite dead yet, and we fancy the old rules circulated by Mr. R. B. Longridge in 1856—the very year, by the way, when THE ENGINEER came into existence—are still retained. Mr. Longridge firmly believed in the spheroidal state, and with the fear of it before his eyes, he instructed firemen that in the event of low water they were on no account to let water into the boiler, and "in such cases, if the engine be not at work, *it must not be started, nor must the safety valve or any other valve be opened.*" If the water were in the spheroidal condition, then any disturbance of the equilibrium might cause a violent explosion, and the only safe course was to let the boiler cool down slowly. On the whole the advice was pretty sound, though the theory on which it was built was erroneous. It is known that cooling the overheated crown by the admission of feed into the body of water in the boiler could not, in fact, cause an explosion, and it is extremely unlikely that the opening of the safety valve or starting the engine would so suddenly relieve the pressure that a violent ebullition would take place and be followed by an exceedingly rapid generation of steam, but nevertheless rapid changes in a boiler are to be deprecated, and to draw the fires and wait is a thoroughly safe course. We should not have alluded to these old theories, interesting as they are, were it not that a correspondent revived the "spheroidal condition" in connection with the Buxton explosion. We have still to wait for Major Clark's report on that accident, but Captain Beames' evidence at the coroner's inquest, of which we give a brief *résumé* on page 684, practically removes the mystery from the domain of philosophy and brings it down to mechanics. It appears to be certain that the safety valves stuck and allowed the generation of such a pressure that the fire-box gave way. Why the valves should have stuck we do not yet know, and it may be hoped that the Ministry of Transport report will throw some light on that rare occurrence. There are one or two other points in connection with the accident that would bear discussion, but it will be more fitting to await Major Clark's report than to touch upon them now.

The immunity from boiler explosions—altogether they only number some hundred or so a year, of which the majority are not serious—which this country enjoys is almost wholly due to the admirable work done by the boiler insurance companies. Here we have an admirable example of what can be achieved when an industry is allowed to look after itself, and when Governmental interference is withheld. The system of inspection instituted by the insurance companies has been a better safeguard against explosions than any rules and regulations that could have been formulated and enforced by Government. Where fatalities occur, the Government can intervene, now through the Ministry of Transport, but formerly through the Board of Trade, but it has no power to punish offenders other than by censuring them and directing them to pay the costs of the inquiry. This very limited power has been sufficient for its purpose, and it is to be hoped it will not be extended. Where the inquiries fail is that they are often too judicial and too frequently neglect technical matters of the highest consequence. If there were more scientists and technologists engaged in them and less legal talent the world would be benefited by the extension of its knowledge of boiler failures.

The Problem of the Panama Canal Slides.

By JOHN STUART, B.A. (Oxon), late Professor of Geology, Instituto Nacional, Panama.

In an article on "Geological Problems and the Panama Canal"—THE ENGINEER, April 24th, 1914—it was stated in these columns that the study of the Culebra landslides would probably occupy the attention of the Canal engineers for many years after the waterway was opened, because of the importance of the question as to the stability of the sides and bottom of Culebra Gorge. And so it has turned out.

In the article referred to it was pointed out that the slides were of different kinds, but the really formidable ones were those which at that time were usually called "structural break and deformation" slides, but which now are more usually called "upheaval slides" or simply "breaks."

These "breaks" were stated to be due to the crushing of the underlying rock which had been weakened by the access of rain water during excavation. As the depth of the excavation increased, this crushed and sodden rock was pushed down and out, as so much plastic material, to the centre of the excavation, where it formed a hump.

After water was allowed to flow into the excavation to form the waterway these humps were, of course, no longer visible, but they made their presence known when ships passing through the Canal went aground. This grounding of passing vessels was often the first indication of the existence of this form of landslide, for often nothing was visible on the banks opposite the hump or shoal.

These landslides are still liable to occur at intervals, seriously reducing the depth of the waterway; it is still uncertain when they will cease, and until that time comes the Canal will not be thoroughly satisfactory as a link in the chain of naval communication between the Atlantic and Pacific Oceans. The Canal was primarily intended for the use of the United States Navy, and notwithstanding its present commercial success, its strategic aspect is still of first-rate importance. For over two years before America entered the Great War the American Government was gambling on the maintenance of the balance of power in Europe. It recognised the fact that if once the balance of forces on the European side were destroyed the Monroe doctrine could not be upheld by the naval and military force which was at that time at the disposal of the United States, and the whole fabric of American imperial policy would fail. It was felt that if the United States could not maintain the merely defensive claims of the Monroe doctrine that doctrine was doomed. For in latter days the doctrine had been changing, and passing from the defensive to intervention, and even to conquest, and the people of Latin America were becoming alarmed at the interference of the North in their affairs.

Apart altogether from naval considerations, the Canal, for nearly two years after its opening, was not even a commercial success, as it has undoubtedly since become. In his report for the fiscal year ending June 30th, 1916, the Governor of the Canal zone stated that the Canal was closed 232 days, between the date of opening, August 15th, 1914, and June 18th, 1916, slightly more than one-third the time. The resulting loss of confidence by the shipping public in the usefulness of the Canal was in a large measure due to the over-optimistic reports given out by the officials of the Canal zone that the slides would shortly cease and permanent service be established by the clearing of the channel. When the shipping public were disappointed in the hope that service would be re-established and maintained with comparatively little delay, they added their criticism to that of those politicians who for their own purposes have always been ready to criticise the work of the Canal engineers.

It is doubtful whether any other activity of the American Government ever received equal publicity through the Press, official reports, lectures, and descriptions of returned visitors and employees as the Panama Canal had during its construction, and it is small wonder that when the unexpected difficulties in the way of slides were first encountered by the Canal engineers they gave rise to considerable criticism in some quarters. Troubles which were clearly due to combination of geological and climatic conditions prevailing there, were attributed by laymen to mistakes of the engineering experts. And yet, although these critics were clearly in the wrong, the fact remained that the schedules, rates and contracts for shipping were being disturbed so frequently that half of the Canal's usefulness had gone.

There is no doubt that for the two years prior to America's entrance into the war, reports of the failure of the Canal were freely circulated in England, Germany and Russia. These reports emanated from geologists and engineers, many of whom were of pro-German sympathies, and they seem to have led many of the people in those countries to believe that the Panama Canal would eventually be abandoned and the Nicaragua route substituted. The earthquake bogey was also alluded to exultantly. These reports, even if they did not exaggerate the importance of the slides or the earthquake menace, at any rate under-estimated the will and energy of the American people. The Panama Canal will unquestionably be kept clear and made to serve its intended purpose, even though it require years and years of dredging and the expenditure of additional millions of dollars to accomplish. The American people will not willingly abandon a project that has so stirred the pride and stimulated the patriotism of the entire country as has the Panama Canal, even though the length of time for its completion and its cost of management far exceed the early calculations.

In the first year of its operation the Canal passed only 6½ million tons of shipping, although Professor Emory R. Johnson predicted it would have 10½ million tons that year. For months and months of the second year it was blocked by the slides, and the managers of the principal steamship lines which ply from coast to coast resolved not to resume traffic by this route for one to two years, possibly longer.

The worst slides by which all traffic on the Canal was at last entirely blocked in the latter part of 1915 occurred within a limited space in the cut near Culebra, now known officially as the Gaillard Cut. They were three in number—the East and West Culebra slides, just opposite each other, and the Cucaracha slide, a little further south on the east side. A few other minor slides also occurred, but the dominant importance of these three was due both to the fact that by far the deepest part of the cut is in this district and to the great development here of the weakest of the geological formations—the "Cucaracha." This is a stratified series of softish material, much of it of a slippery, clayey nature and so unconsolidated as to be unable to sustain any considerable load. The prominent hills on either side of the Canal are composed of massive rocks, hard intrusive basalts and tuffs, and though some portions had cracked and broken away with the withdrawal of the support of the adjacent material, there was every reason to trust to their general solidity, though, like the stratified material, they are cut by numerous faults which are a certain cause of weakness. It was evident, therefore, that the seriousness of the trouble called for the careful study of the best expert talent in the country.

In 1915, at the request of President Wilson, the National Academy of Sciences appointed, among others, the following geologists to investigate and report on the control of the Panama landslides:—President C. R. Van Hise, University of Wisconsin (chairman); General H. L. Abbott, Cambridge, Mass.; and Dr. G. F. Becker, United States Geological Survey. In 1917 Dr. Becker (United States Geological Survey, Professional Paper, 98–N) reported the results of his investigations in a paper entitled "Mechanics of the Panama Canal Slides." He points out that the slides are of two kinds—mere superficial slips on joint planes or other slippery surfaces and deeper-seated "breaks," as they are known by the engineers. It is only with the latter that Dr. Becker deals. As a result of his field work, he was able to formulate a theory of these slides, the mechanics of which he shows are reducible to identity with a soluble mathematical problem in capillarity, and he also shows that there is a sharp limit to the distance to which slides can extend. During the progress of a large slide, upheaval of the bottom of the Canal may take place from time to time, showing that deformation of the rocks extends to a certain depth below the deepest excavation. Movement of the slides perhaps never entirely ceases, but it varies greatly in velocity, from a fraction of an inch a day to many yards.

In estimating the stresses and strains at the base of a cliff, Dr. Becker gives reasons for supposing that the resistance to crushing is about 8½ times the resistance to shear. Assuming that the resistance to crushing of the Cucaracha formation is about 2760 lb. to the square inch—for that of the poorest sandstones

is somewhat less than 3000 lb.—this would imply that for "Cucaracha" the resistance to shear is 325 lb. per square inch. This is the weight of a column of rock of a density of 2.5 times that of water and 300ft. high.

According to the theory Dr. Becker sets forth, a limit is put to the vertical height of a cliff corresponding to the rock of which it is composed. In granite, for example, this limit allows a face of 3700ft. From results obtained by the United States Geological Survey, it appears that granites show resistances to compression up to 34,000 lb. per square inch. On Dr. Becker's theory this would correspond to a cliff 3700ft. high. The brow of El Capitan, in the Yosemite Valley, stands 3100ft. above the Valley, but the top of the dome, some 2000ft. back from the brow, is about 500ft. higher. From this it is very probable that what has occurred at Culebra as a result of man's interference, is constantly occurring in nature as a result of erosion acting through long periods of geological time.

Until slides began to give trouble, the banks of the cut were very steep, quite too steep, in fact, as everyone would now concede, and the precaution of giving the banks a low slope might have prevented the occurrence of slides. When breaks have opened parallel to the rock face, a horizontal shear has started at the base of the cliff, and outward movement can be checked only by the removal of material and the sloping back of the surface of the unstable mass.

But even here Dr. Becker is not very optimistic. He believes that the precaution of giving the banks a low slope might have prevented the occurrence of slides, but as a remedial measure, after breaks have developed to a considerable extent, he is not very hopeful. He states that after the basal curve has developed into a crack, the material overlying it is either in motion or in unstable equilibrium, and sooner or later all, or nearly all, of it will reach the bottom. Slides of origin similar to those of the Culebra Cut are by no means confined to the Canal zone. In Dr. Becker's opinion the banks of cuts should be watched with extreme care, and the moment any cracks make their appearance all other work should be suspended until a safe slope has been established. In the case of such breaks, prevention is decidedly better than cure.

Another member of the Committee of the National Academy of Sciences that went to Panama to study the slides and prepare a report upon them was even less optimistic than Dr. Becker. This authority, Dr. J. C. Branner, President Emeritus of Stanford University, California, states that when one sees the sliding area extending further and further away from the Canal, the volume of the moving masses gradually getting bigger and bigger, and the very hills themselves toppling over, and, adding to the confusion, trees, mud, rocks and great blocks of basalt as big as houses, and when he sees that these millions of tons that have to be removed cost about 60 cents a cubic yard, he feels that some way ought to be found to make the hills stay where they are. Dr. Brauner, as the result of forty years of study of landslides in tropical countries, believes that the only way to make the hills "stay where they are" is to prevent the heavy rainfall from entering the ground adjacent to the Canal. It is somewhat questionable whether this can be accomplished, and, if not, there seems no alternative but the complete removal of the threatening hills, the remedy of which Dr. Becker was not too hopeful.

In spite of the rather disappointing reports of the theoretical geologists, the Slide Commission appointed by President Wilson took a more practical view of the matter, and submitted various recommendations. The Commission believed that the heavy rainfall had an important influence in producing slides. The average annual rainfall in the Culebra district is about 85in. per annum, concentrated in eight months of the year. Notwithstanding the ill-success of the French company in preventing slides by surface drainage, the Commission believed that every available device should be used to keep water away from the slides.

The Commission suggested that the deep cracks which formed in the earth adjacent to the slides during the dry season as the ground shrinks, should be systematically filled, in order that the surface water might not be led into them. It also suggested drainage by tunnels driven underneath sliding ground in undisturbed material.

The most serious possibility in connection with the sliding ground is that the high hills along the deepest part of the Gaillard Cut may move toward the Canal. The Commission says that these hills, so far as it can determine, are composed of intrusive bodies of basalt or masses of the hard Obispo tuff. So far as can be judged, the hard rock masses which form these hills extend far into the earth, and are self-supporting. Rock may slough off from them, but there is no evidence that they will collapse.

To assist in determining the likelihood of future slides, the Commission recommended a careful system of surveys to detect incipient movements of the ground and deep core boring on each side of the Canal with a drill giving large cores. They advocated as a matter of scientific interest, the making of an accurate triangulation of Gold Hill, Contractor's Hill, Culebra Hill and Zion Hill, and this has been done. By checks made at frequent intervals the slightest movement on the part of any of the four hills would be disclosed at once. No movement of any kind has taken place.

In conclusion, the Commission stated that while it realised that slides might be a considerable maintenance charge upon the Canal for a number of years and that possibly trouble in the Culebra district might perhaps again close the Canal, it believed that after the slides they were investigating had been removed, navigation through the Canal was not likely again to be seriously interrupted.

Such were the conflicting opinions which confronted General Goethals, the practical engineer on whose shoulders the whole responsibility fell, and he met the difficulty in his usual practical way. Some years previously before the Canal had been opened and when slides first began to give trouble, Mr. Goethals was asked what was his solution of the slide problem. His reply at that time was, "Patience and digging"; and his treatment of the much more formidable conditions at Culebra Cut after the opening was practically the same.

On its practical side, General Goethal's account was a masterpiece in the technical reporting of facts, while on the theoretical side, his classification of Panama slips was by no means the least valuable feature of the report. The first and the simplest are slips of the kind discussed in the ordinary retaining wall theory, and are always of small size. Secondly, are the slides of the ship-launching type, where a natural slip-plane exists on which the superincumbent mass begins to slide under critical conditions of lubrication, *e.g.*, the great Cucaracha slide. Thirdly, are slips of the plastic flow kind, a rare and highly unmanageable type. They are represented in the remarkable series of slips in valleys of the St. Lawrence River tributaries in Quebec. They are also represented in the recent subsidence of a large cement plant at Hudson, N.Y. According to the description of the Culebra slides, these, too, are of the plastic flow type. In these latter slips a clay-like sub-soil becomes suddenly plastic, not to say semi-liquid, under certain conditions of moisture and pressure.

In the case of the Quebec slides, *e.g.*, the slip which overwhelmed the village of Notre Dame de Salette in the Lièvre Valley in 1908, it is obvious that not only was there no warning, but every assurance could be drawn from long-continued permanence of conditions that the soil was stable. The slip, of course, disproved it, and just as surely would make any future prediction in the same region valueless.

On the other hand, at Culebra the situation is somewhat different, and by no means equally hopeless from the predicting view-point. The flows that occurred there were relatively slow movements. The soils that crushed out under the superincumbent weight did not fail as suddenly or completely; they have no such critical range as exhibited in other slides of this type. Adjustment should therefore be easier, and the permanence of the result should be more dependable.

Thus, although General Goethals did not minimise the serious character of the great earth movements that had blocked the Canal, he believed they would come to an end when the earth masses had reached a condition of stability, and that in a decade or two of months, and not of years, as the pessimists believed.

The big slides that blocked the Canal were removed sufficiently about April 15th, 1916, to permit ships again to use the waterway. The dredges continued at work, however, until they had not only brought the channel to its former size, but, by April 1st, 1917, had also made the part where maximum sliding occurred more than 200ft. wider than it was before the temporary stoppage of traffic. After January 1st, 1917, only a little dredging was done, and by February 1st, 1918, it was practically discontinued. Of course, a little dredging must always go on for general maintenance.

On August 30th, 1916, a large boulder slid into the channel, and, because of its menacing position, caused navigation to be suspended until it could be blasted out. Because of its great hardness, the rock was not completely removed until September 7th, 1916. Since that seven-day interruption to navigation in 1916 the Canal has given absolutely satisfactory and uninterrupted service, thus showing the groundlessness of the fears expressed in a portion of the American Press.

The yearly reports of the governors of the Panama Canal since 1916 continue to be favourable. In that for 1919 it is stated that the great Cucaracha slide from which a total of 5,063,852 cubic yards has been removed by dredges, had been quiescent throughout the year, and the more disquieting Culebra slides on the northern side of the divide had been fairly quiescent. There had been removed from the Culebra slides to date by dredges the vast total of 25,000,000 cubic yards of material. Hydraulic work was being done by sluicing down and reducing the weight of the banks where slides had occurred. At no time during the year had there been any difficulty in maintaining the full width and depth of the channel in the formerly dreaded Culebra slides region. Traffic through the Canal for the year ending June 30th, 1920, exceeded that of any previous year.

Literature.

The Working of Steel, Annealing, Heat Treating and Hardening of Carbon and Alloy Steel. By F. H. Colvin and K. A. Juthe. London: McGraw-Hill Book Company, 6 and 8, Bouverie-street, E.C. 4. Price 18s. net.

The authors of this volume start out with the idea that the automobile industry has done much to develop the use of new alloys in steel making. This obsession appears frequently in papers read before automobile societies, and is regularly accepted without comment. It might be assumed that the requirements of the automobile industry having been clearly expressed and completely appreciated, the steel makers then conferred with their expert advisers and produced the materials currently used in the trade. This hypothesis is very flattering but quite erroneous. The kinds of steel used by and recommended to the automobile trade in its early days depended less on metallurgical than on commercial considerations. It seems likely that both nickel steel and nickel-chromium steel came first into general use for structural engineering purposes in the form of material discarded from the manufacture of guns and armour. Such material was both cheap and plentiful, and if not always satisfactory it was at best a great advance on carbon steel, and was, moreover, already associated with well-defined processes of heat treatment. When the automobile trade and other branches of engineering required more alloy steel or better alloy steel than the discard market could supply, it still asked for and received the old 3½ per cent. nickel gun steel or some variant of it, and the old armour nickel-chrome steel or some variant containing less nickel or less chromium or less of both, either to save expense or to facilitate working.

If the fabled course of events were even now materialised and engineers competent to formulate understandable demands associated themselves with steel makers commercially unbiassed but possessed of knowledge spread to the limits of their scientific art, it is doubtful that present-day practice in relation to the uses of alloy steel would be confirmed. The possibility of such a conference is extremely remote. Meanwhile, books with alluring titles which have been compiled from catalogue knowledge and advertising material become more numerous, and make it increasingly difficult for the earnest student, dependent mainly on book knowledge, to acquire harmonious ideas.

Messrs. Colvin and Juthe say their book is "not intended as a treatise on steel making or metallurgy in any sense." We are glad of this admission, for no competent steel maker or metallurgist could read the first chapter, which treats of steel making, without feeling grateful to the authors for confining it to eleven pages. The book comprises twelve chapters dealing with the Composition and Properties of Steels; the Effects of Alloys; Case-hardening Forging; High-speed Steels, &c. As some of the chapters are compiled principally from traders' catalogues, they are, mercifully, more instructive than Chapter I. The compilation is done, however, without critical discretion and with slight regard to systematic arrangement of material quoted from different sources. In discussing the influence of chemical elements on the properties of steel, silicon is described as "a sort of adjustor"; sulphur and phosphorus as "lubricants," and nickel as "a protecting support of structure and aid to stability." On another page sulphur is classified in its effects as "a strength sapper," and phosphorus as "the weak link." Not even the avowed limitation of the book make such loose expressions defensible, but they will give our readers an idea of the probable value to them of the volume, for which a title more truly descriptive than "The Working of Steel" might have been found.

BOOKS RECEIVED.

The Society of Naval Architects and Marine Engineers Year Book, 1921. New York: Engineering Societies Building, 29, West 39th-street.

Electric Lighting in Factories and Workshops. By Leon Gaster and J. S. Dow. London: Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, W.C. 2. Price 6d. net.

Fifty Years of Electricity: The Memories of an Electrical Engineer. By J. A. Fleming, F.R.S. London: The Wireless Press, Limited, 12–13, Henrietta-street, W.C. 2. Price 30s. net.

The Chemical and Metallographic Examination of Iron, Steel and Brass. By W. T. Hall and R. S. Williams. London: McGraw-Hill Publishing Company, Limited, 6 and 8, Bouverie-street, E.C. 4. Price 30s. net.

Thirteenth Annual Report of the Hydro-electric Power Commission of the Province of Ontario for the year ending October 31st, 1920. Volume I. Printed by order of the Legislative Assembly of Ontario. Toronto: Clarkson W. James.

Benzine and Mineral Lubricants: Their Production, Testing and Uses. By Dr. J. Formanek. Translated from the German by Charles Salter. London: Scott, Greenwood and Son, 8, Broadway, Ludgate-hill, E.C. 4. Price 15s. net.

Marine Diesel Engine and Semi-Diesel Engine Operation and Management and Control of the Auxiliary Machinery. Embodying the practice of Vickers, Limited. By Engineer-Lieutenant Harold Atkinson. London: E. and F. N. Spon, Limited, 57, Haymarket, S.W. 1. Price 2s. net.

Buxton Boiler Explosion.

At the resumed inquest at Buxton on the explosion of a London and North-Western locomotive, Captain Beames gave evidence. He said the boiler in question, which was sixteen years old, was in excellent condition. It had been repaired in July, 1921. The whole engine had been brought to Crewe and a very careful examination had been made by experts, and they had come to the conclusion that the first part of the boiler which fractured was the crown of the fire-box. That was very clearly shown by certain markings on the back of the fire hole, on the plate of the fire-box, showing, in their opinion, that the plate was in position when another plate came down. They had to look for the cause of that particular plate coming down. The only thing which had been found fractured were two roofing bar links on the left back side of the boiler. Some of the roofing bar pins were bent, and others were sheered through. Tests which had been carried out of the material of which the bars were made, showed that the roofing bar links were made of the most excellent material. They had also carried out tests of the plates from which the cover of the fire-box was made, and they found that they more than conformed with the British standard specification. That brought them to the next point, to ask what markings on the plates convinced him and his colleagues that it was the top part of the fire-box that was the first to go. To satisfy themselves they carried out tests on a similar boiler two years older, taken off an engine in traffic, and they tested it to destruction. They had got an hydraulic pressure of 600 lb. to the square inch on the boiler when one of the roofing bar bolts was found to be partially fractured, and that finished the test. The fire-box was in excellent condition still, but the crown had sagged down slightly.

The evidence given before the Coroner and the Ministry of Transport officials pointed to the fact that the steam gauge was reported to be registering 300 lb. prior to the accident. The gauge had been tested in his presence and the presence of the Ministry of Transport officials and was found practically correct, or within a matter of 10 lb. either way, which was quite immaterial. They had had evidence put before them which was really to the effect that up to a certain date the safety valves of that engine had blown freely and consistently. That was up to either September or October. Subsequent to that date it did not seem, as far as the evidence went, that the safety valve of that engine had been known to blow off. They therefore carried out tests on the safety valve, or what remained of it, with a view to finding out if the valve had stuck. There were two valves, one of which was blown out, and the lever bent right round. The other was in place, the lever and spring being intact. They had carried out several examinations and tests, but had not found any evidence—conclusive evidence—to show that that valve was stuck at the time. It was a most unusual occurrence for a safety valve to stick. There were 3400 engines on the London and North-Western Railway, each of which had two of those valves, and they could not find in the history of any man in the employment of the company evidence of a safety valve sticking. That was a defect that had been known to take place, but not on any engine, so far as had been recorded, on the London and North-Western. Yet his own impression was that it was a defect in the safety valve that caused the accident. The theory that the engine was short of water was negatived by the state of the crown of the fire-box. Subsequently the jury recorded their verdict that the fatalities were caused by the accidental bursting of a locomotive boiler.

A 5½-Inch Capstan Lathe.

A 5½in. centre capstan lathe of new design is now being put on the market by Pollock and Macnab, Limited, Bredbury, near Stockport, which, whilst retaining all features tending to quickness and handiness of operation, is much more powerful than lathes of this size usually are. A general view of the machine, provided with an automatic chuck of 1¼in. capacity, a roller bar feed, a chasing saddle, power sliding feeds and power feeds to the capstan slide, is given above.

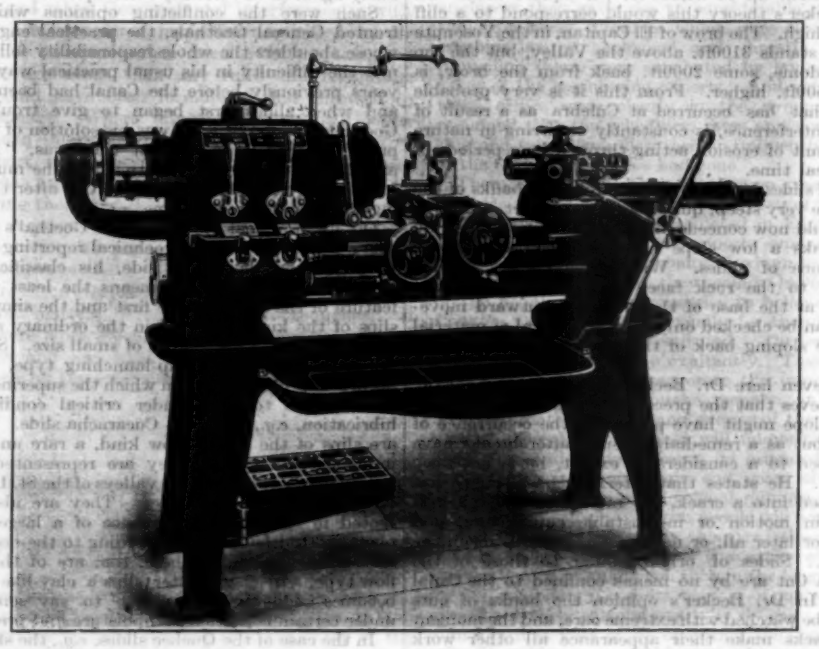


FIG. 1—5½-INCH CAPSTAN LATHE

The lathe is fitted with an all-gear headstock, a plan of which is given in Fig. 2. The drive is transmitted through the two independent friction pulleys shown, four speed changes being provided in the headstock. This construction gives either four spindle speeds and a reverse, viz., by driving one pulley with an open belt and the other pulley with a crossed belt, or alternatively by driving both pulleys by open belts but at different speeds eight spindle speeds. Being operated by means of friction clutches either pulley may be engaged instantaneously. The change from open to back gear is also effected through friction clutches. The fast and slow ratios are obtained through a positive concentric clutch sliding on a castellated shaft. The various speed changes are interlocked. The gear wheels are all of heat-treated steel. The spindle bearings are of phosphor-bronze, and there is a ball thrust bearing, while all the revolving shafts other than the spindle run in ball bearings. Front and end views of the automatic collet chuck for bar work are given in the drawing, Fig. 3. This chuck is quickly and easily operated, the purchase obtained through the chuck handle being multiplied by means of toggle levers as shown. The collets consist of four sections for each size of bar, and when the chuck is opened they are positively released. All wearing surfaces are hardened. The chuck may be opened and closed without stopping the lathe spindle. To compensate for slight variations in the diameter of the bars, adjustment is provided.

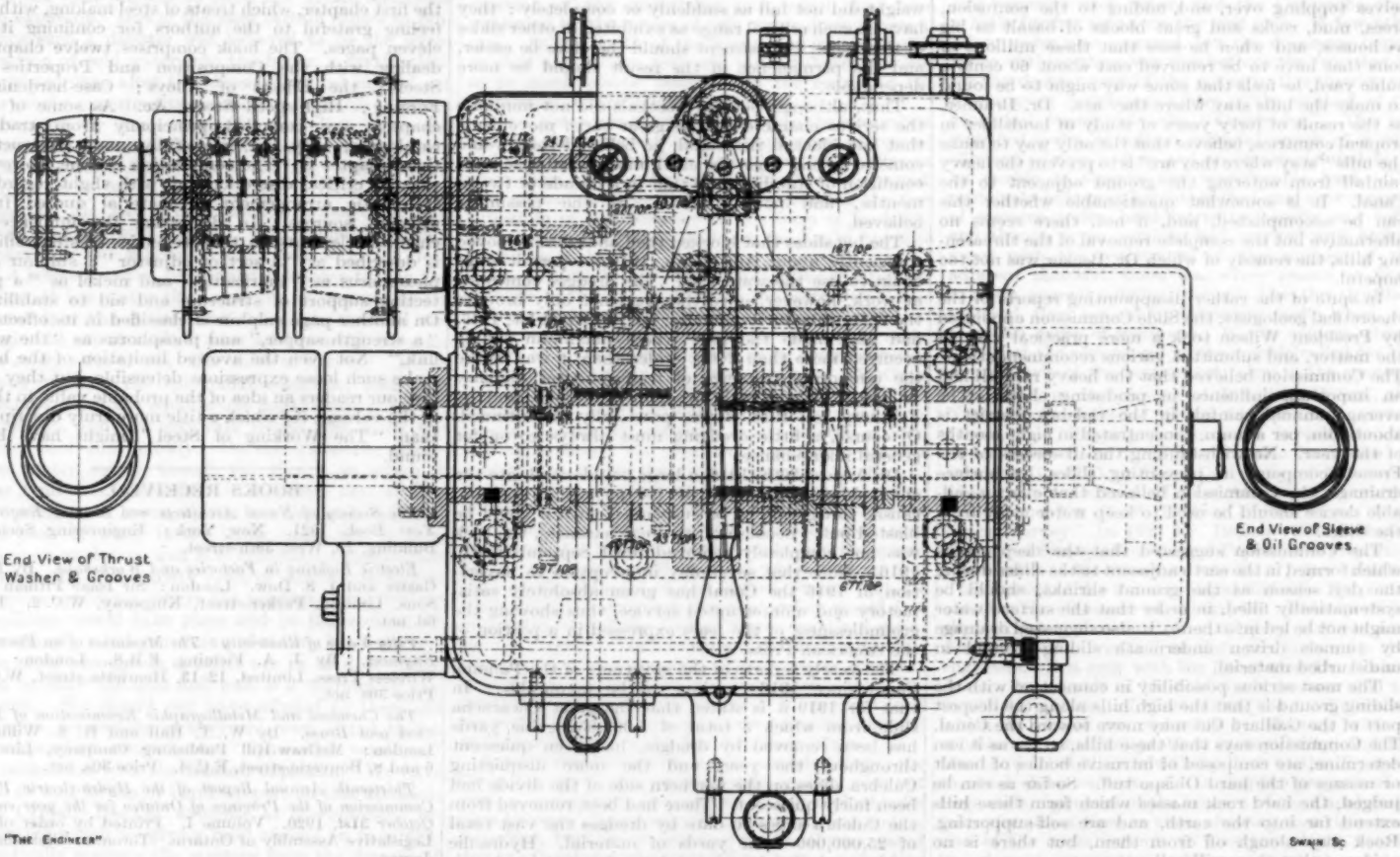


FIG. 2—ALL-GEAR HEADSTOCK OF 5½-INCH CAPSTAN LATHE

The roller feed mechanism illustrated in the drawings, in Fig. 4 is designed to feed the bar forward by the action of rollers which are caused to rotate by the machine spindle whenever the chuck is opened by the operator. The collet chuck handle, on being moved to the right, first opens the chuck, and by a further movement pushes the rod A, which, depressing the plunger B, causes the friction ring C to grip the wheel D, and thus stop its rotation. As the casing and spindle of the mechanism continue to revolve around the wheel D the gear wheels E drive the worms F and worm wheels G and give motion to the rolls H, which make frictional contact with the bar X and feed it through the spindle until the forward motion is arrested by a stop gauge. The rolls can be adjusted by means of the screws J, and

for centralising the bar X the screws K are provided.

The chasing saddle can be clamped to the bed when required by means of a lever actuating a long taper strip. Three sliding feeds are provided, and are operated by means of a trip and feed-engaging lever placed on the saddle. The apron carries four automatic trips and dead stops, the latter being adjustable independently or simultaneously. The cross slide, operated by a hand wheel and screw, has two dead stops in each direction, and is fitted with front and rear tool posts. Chasing is effected by means of leaders and nuts. Three leader changes are provided in the feed box, enabling three pitches to be cut from one leader and nut. A reverse gear is fitted for cutting left-hand threads, and a quick withdraw lever simultaneously engages or disengages the tool and nut when chasing is being carried out. The chasing and feed mechanisms are interlocked.

The capstan carriage can be clamped in any position along the bed, and the slide can be clamped at any position in the stroke. The capstan is hexagonal and is bored through to permit of the passage of long bars. Three feeds, together with six automatic trips and dead stops, are provided, and the stop barrel rotates in unison with the capstan. The gears are of heat-treated steel, and the revolving shafts run in ball bearings. The feed shaft is gear-driven from the main spindle, the drive being totally enclosed. As the intermediate gear runs in ball bearings, it requires only occasional lubrication. All the headstock gear wheels run in oil, and individual oilers have been largely superseded by oil channels and syphon oilers, which distribute the lubricant by internal passages to a number of points.

The following are the leading dimensions of the lathe:—Height of centres, 5¼in.; swing over bed, 11in.; swing over cross slide, 5¼in.; maximum distance from spindle to capstan face, 23in.; length of bed, 4ft. 8in. The headstock has either four or eight speeds according to the arrangement of the belt drives. In the former case, with a pulley speed of 500 revolutions per minute, the spindle speeds available are 50, 100, 200 and 400 revolutions per minute. As an eight-speed headstock with pulley speeds of 400 and 600 respectively the following speeds are available: 40, 60, 80, 120, 160, 240, 320 and 480 revolutions per minute. The pulley diameter is 8in., width of belt 2in., hole through the spindle $1^{9}/_{16}$in., and the maximum diameter admitted through the chuck 1¼in. The gross weight of the machine is 18½ cwt.

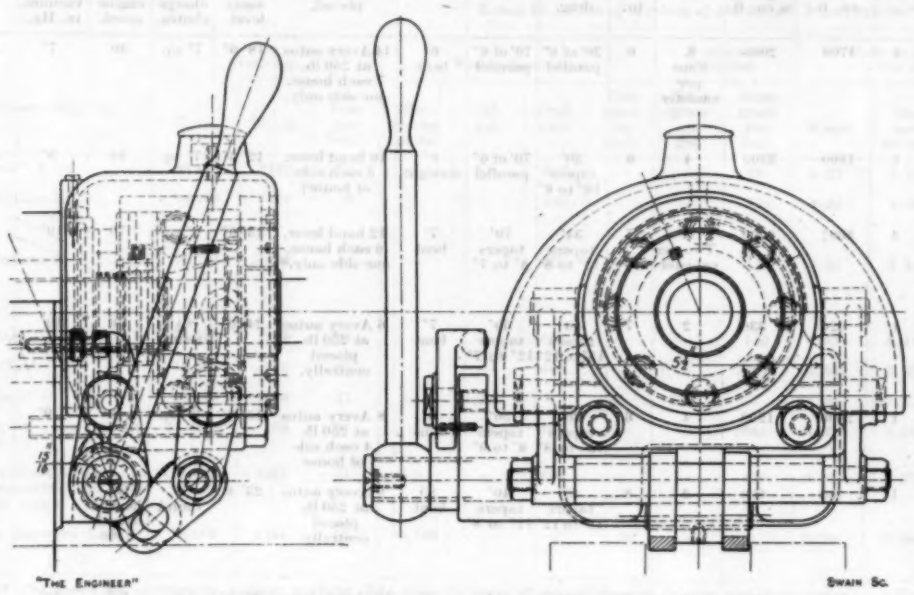


FIG. 3—SIDE AND FRONT VIEWS OF AUTOMATIC COLLET CHUCK

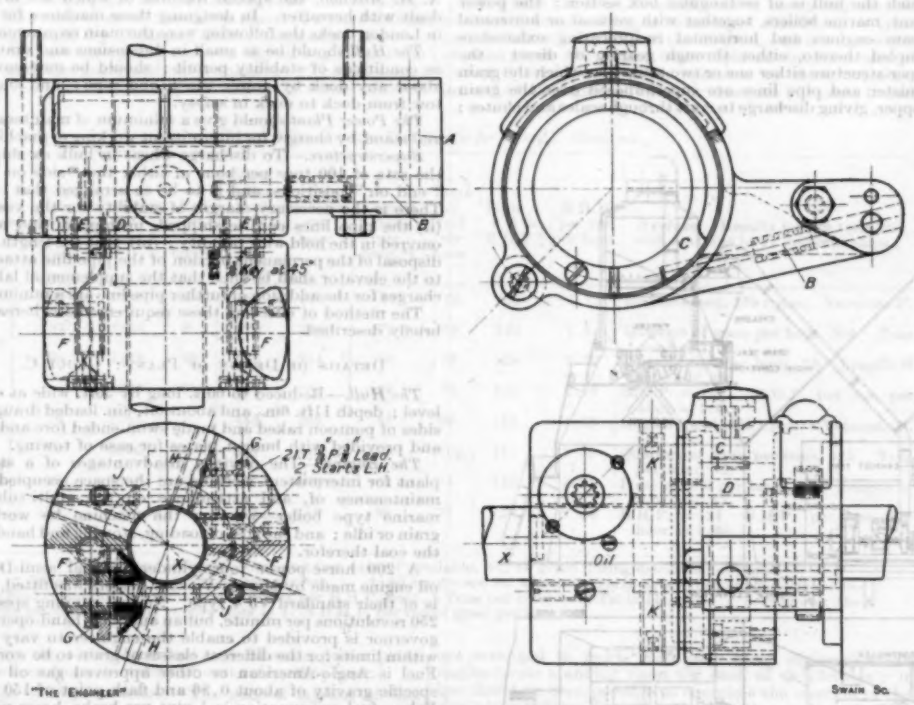


FIG. 4—ROLLER FEED MECHANISM

The Disposal of House Refuse.

THE Committee appointed by the Conference which was originally convened by the Westminster City Council to investigate the best means of house refuse disposal, issued its final report in November last, and a copy of that document, which has just been published, lies before us. It contains so little matter which is not of first-rate interest that it is difficult to abstract, and we shall do no more, therefore, than indicate in bare outline the ground that it covers, leaving those who desire to pursue the subject further to obtain for themselves copies of the report.

It appears that the total amount of refuse collected each year in the Administrative County of London is about 1,500,000 tons, say, about 5000 tons for each working day. The population of the county is very nearly 4½ millions, the number of hereditaments over 808,000, and the area about 117 square miles. In the work of collection and disposal 1204 single-horse vans, 38 pair-horse vans, 61 motor lorries and 17 trailers, or a total of 1320 vehicles, are employed. Of the total quantity of refuse, 670,000 tons, or 44.66 per cent., are taken away by barge to shoot; 250,000 tons, or 16.66 per cent., are taken away by rail to shoot; 280,000 tons, or 18.66 per cent., are burnt in destructors; and 300,000 tons, or 20 per cent., are disposed of at local shoots, by sale, &c. Practically 80 per cent. of London's refuse is, therefore, at present disposed of by dumping. The cost of disposing of this refuse is estimated at £600,000 per annum, or £2000 per diem, and 8s. per ton.

In carrying out its investigations the Committee visited a number of installations for refuse disposal, and it gives in its report descriptions of (*a*) Ramsay's patented refuse destructor; (*b*) the Borough of Hornsey refuse destructor; (*c*) the scheme of disposal by destruction, developed by Mr. C. Newton Russell, A.M. Inst. C.E., the borough electrical engineer of Shoreditch; (*d*) the pulverising or crushing of refuse at Southwark; and (*e*) the refuse salvage plant at St. Marylebone. Each installation is dealt with in a concise and eminently practical manner so that a really excellent impression of each and all is given to the reader.

The Committee then proceeds to discuss, in turn, the composition of house refuse; the value of refuse for agricultural purposes; and the practicability of concerted action among the various authorities concerned regarding the disposal of refuse. It then passes on to consider the "best means" of disposal and reviews, in turn, (*a*) dumping on the land; (*b*) dumping in the sea; (*c*) burning in destructors; (*d*) pulverising by machinery; and (*e*) screening and grading by machinery; and it concludes by saying:—

"We believe that the great bulk of the refuse can be converted into marketable commodities and can be sold in relief of the rates. To put an extreme case from the economic point of view only: If the cost of erecting and working a salvage plant were less than the cost of barging or railing to dump, even if no purchasers of the salved refuse could be found, and the material had to be given away, salvage would still be justified. . . . Screening and crushing greatly reduce bulk and render the material largely innocuous, thus meeting the objection to dumping from the public health standpoint. Our estimate of the present average cost of disposal throughout London is 8s. per ton (it is probably more). By every 1s. per ton that figure is reduced, the ratepayers of London will benefit to the extent of £75,000. . . . Every Borough Council has furnaces to feed, and a salvage plant will produce at least 25 tons of fuel out of every 100 tons of refuse dealt with. . . . It appears to us that the application of the most suitable method (of disposal) in any particular Borough in the Metropolis is a matter for determination by the Council of that Borough. Profiting by such enterprise and vision as its members and officers bring to bear on the subject, and with their special knowledge of local conditions and circumstances, each Council should evolve and perfect the method or methods best suited to its particular district. It is a question for the most serious consideration of each Council concerned whether the time has not come for the abandonment of the easier but more costly and insanitary methods of refuse disposal. We can understand any public body hesitating to incur capital expenditure at the present time, but if it can be shown that by such expenditure immediate and permanent saving, as well as benefit to health, will accrue, we venture to suggest that the Borough Councils will be well advised to break away from old methods and introduce (experimentally at first) those which we think must commend themselves as desirable, and which we confidently predict will, in practice, be found to be financially advantageous."

Discharge of Grain Cargoes in the Port of London by Pneumatic Elevators.*

By R. E. KNIGHT, M.C., of London, Associate Member.

INTRODUCTORY.

BUCKET elevators have certain advantages for handling grain in bulk, and many of these elevators are in use in the Port of London. The merits of this class of machine are before the Institution in a paper on "Conveying and Elevating Machinery," by Gardiner Mitchell. The present paper deals only with the pneumatic discharge of grain from ships; and more particularly with two modern examples of floating and quayside plants in which oil engines or motors and high-speed rotary exhausters have replaced the more usual vertical or horizontal compound steam engines and reciprocating exhausters as the main power plant of the installation. The invention of the pneumatic elevator on a commercial basis appears to be due to the late Mr. F. E. Duckham.

GENERAL PRINCIPLES OF A PNEUMATIC ELEVATOR.

Some form of power plant driving some form of air-exhausting plant, together with the necessary fuel, is enclosed in a steel pontoon or hull. On the deck of this hull, or at a suitable distance above it, is placed a grain receiver or canister to which the air-exhausting plant is connected. Suitable internally armoured flexible and/or rigid pipes provided with nozzles are led from the canister to the grain in the hold of the craft to be discharged. These nozzles are kept buried in the grain, air rushes up the pipes in an endeavour to destroy the vacuum permanently maintained in the circuit, and in so doing carries the grain with it, which is deposited in the canister. By means of an automatic or mechanical air lock of the tipper or rotary wheel valve type, the grain is continuously discharged from the canister (without loss of vacuum therein) to some form of grain hopper situated at a suitable height above the deck, whence the grain is delivered either direct to craft or weighed out thereto through scales and chutes either in bulk or sack as may be required. The higher the proportion of grain raised to air displaced at any given vacuum, the more efficient will the machine be, and the less horse-power per ton of grain raised will be required. Such efficiencies are usually in the neighbourhood of 5 per cent. or less.

ADVANTAGES FOR DISCHARGE OF GRAIN EX SHIP.

In spite of the very low order of efficiency obtained from pneumatic plants, they have many advantages for ship discharge, which may be here summarised as under:—(*a*) No reasonable limitation as to size of ship discharged. (*b*) Can work any kind of parcel and any method of stowage with special advantage in cases where different parcels are stowed superimposed in the same hold and separated from each other by "matts" only. (*c*) Sim-

* The Institution of Mechanical Engineers.

plicity and rapidity of shipping and unshipping. (*d*) Absence of "trimming" in the hold and dust thereby entailed. (*e*) No damage or loss of weight to grain, but on the contrary, aeration and cleaning during discharge. (*f*) Use of ship's gear not required. (*g*) Other cargoes can be removed from between decks whilst discharge is being effected. (*h*) Work in bad weather due to minimum removal of hatches over hold. (*i*) Permanent crew from numerical standpoint about the same; but extra labour for ploughing gangs in the hold, and winch end men on the ship's deck are eliminated, as are also the heavy charges for ropes, ploughboards, and other gear. (*j*) Output in tons per hour may be higher and usually is so; the rate of discharge for all types of machine, however, depends on the rate of delivery from the scales rather than on the maximum intake capacity of the plant, and therefore the conditions of delivery must largely affect the final rate of output. (*k*) Reliability and freedom from breakdown caused by obstructions due to foreign matter in the grain or other cause. (*l*) Costs of working and maintenance may be broadly regarded as being made up of engineering charges and bulk grain charges. It will be seen from the table referred to later, which gives the engineering charges only, that the pneumatic elevator compares favourably in this respect, except in the matter of capital cost

The general tendency of modern docks is to install pneumatic machines for floating discharge ex ship.

Tabular Statement of Leading Features.

The leading features of the various floating pneumatic plant working in the London docks are set out in Table I. It will be seen from the table that these machines may be grouped as under:—

Group A comprises the machines first constructed in which the hull is of rectangular box section; the power plant, marine boilers, together with vertical or horizontal steam engines and horizontal reciprocating exhausters coupled thereto, either through gearing or direct; the super-structure either one or two towers, in which the grain canister and pipe lines are superimposed over the grain hopper, giving discharge to craft through scales and chutes; and the working position of the elevator "side on" to the ship under discharge.

Group B includes machines subsequently constructed or converted, in which the hull power and air-exhausting plant are similar to Group A, but in which the super-structure consists of a single grain canister and pipe line placed on the forward end of the pontoon; the grain is re-elevated therefrom by bucket elevator to the grain hopper and weigh house on the after end of the pontoon, whence maximum discharge can be effected to craft on either side of the elevator or any desired proportion thereof to craft on both sides of the elevator; and the working position of the elevator may be either "side on" or "end on" to the ship under discharge, the pipe line being slewable for this purpose.

Group C comprises the machines most recently constructed to the requirements of the Port Authority and the designs of their chief engineer, assisted by the late Mr. A. H. Mitchell, the special features of which are briefly dealt with hereafter. In designing these machines for use in London docks the following were the main requirements.

The Hull should be as small in dimensions and draught as conditions of stability permit; should be manœuvred about any dock by power winch and rope; and should tow from dock to dock in safety.

The Power Plant should give a minimum of maintenance and stand-by charges for intermittent working of machines.

Superstructure.—To discharge wheat in bulk ex ship at the rate of 100 tons per hour in either the "side on" or "end on" positions, and is to be so arranged that:—(i) There is the necessary margin of stability for the vessel; (ii) the pipe lines can be shipped, unshipped, and manœuvred in the hold with rapidity; (iii) that the length and disposal of the permanent portion of the pipe line attached to the elevator shall be such that the supplemental labour charges for the addition of further pipe line are a minimum.

The method of effecting these requirements is hereafter briefly described.

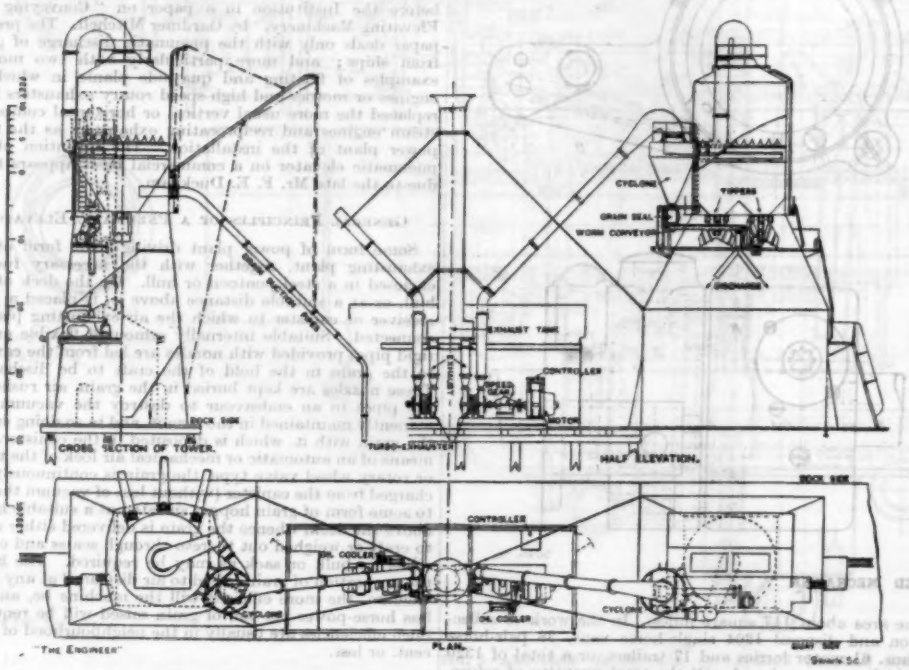
Table I.—*Particulars of Machines.*

Name. Displacement in tons. When built.	Power plant. Engine.	Power plant. Pumps.	Power plant. Drive to pumps.	Power plant. Pump constant.*	Grain canisters. No. of.	Grain canisters. Capacity in cu. ft.	Grain canisters. Cyclones or stive rooms, capacity in cu. ft.	Grain intake pipes. No. of.	Grain intake pipes. Dia. in in.	Grain intake pipes. Horizontal drag.	Grain intake pipes. Vertical lift.	Grain intake pipes. Type of nozzle.	Weigh-house. No. and type of scales and how placed.	Weigh-house. Height from floor to water level.	Weigh-house. Dia. of discharge chutes.	Remarks. For wheat discharge. Normal engine speed.	Remarks. For wheat discharge. Normal vacuum. in. Hg.	Remarks. Group letter.
"Rapid." 1000. 1905.	Steam. Horizontal compound surface condensing. H.P. 28" | D.A. L.P. 54" / cyls.	4 D.A. Horizont'l pumps. Bore 4' 1" Stroke 4'	Tail-rods from pistons	420	2	1700	2000	8. Four per canister	6	30' of 6" parallel	70' of 6" parallel	6" bent	14 Avery autos at 250 lb. 7 each house, one side only.	18' 6"	7" sq.	50	7"	A.
"Mark Lane No. 2." 520. 1897.	As above. Stroke 48". H.P. 22" | D.A. L.P. 42" / cyls.	2 pumps as above. Bore 4' Stroke 4'	Tail-rods from pistons	200	1	1800	3300	4	6	30' tapers 10" to 6"	70' of 6" parallel	6" straight.	10 hand lever. 5 each side of house†	12' 3"	7" sq.	40	8"	A.
"Mark Lane No. 3." 880. 1902.	As above, but vertical. Stroke 30". H.P. 19" | D.A. L.P. 38" / cyls.	4 pumps as above. Bore 4' Stroke 5'	3 to 1 gear reduction from engine	500	2	460‡	2500	4. Two per canister	7	34' tapers 12" to 8"	70' tapers 8" to 7"	7" bent	12 hand lever. 6 each house, one side only.†	13' 0"	6" sq.	70	10"	A.
"Chicago." 610. 1898. Reconstructed 1911.	As above. Horizontal. Stroke 48". H.P. 22" | D.A. L.P. 42" / cyls.	2 pumps as above. Bore 4' 6" Stroke 4'	Tail-rods from pistons	254	1	320	330	2	7	40' tapers 15" to 12"	50' tapers 12" to 7"	7" bent	6 Avery autos at 250 lb. placed centrally.	24' 0"	6½" round	36	10"	B.
"New York." 650. 1902.	As above. Stroke 48". H.P. 22" | D.A. L.P. 49" / cyls.	2 pumps as above. Bore 4' 8" Stroke 4'	Tail-rods from pistons	272	1	2000	1200	4	6	30' tapers 13" to 8"	50' tapers 8" to 6"	6" bent	8 Avery autos at 250 lb. 4 each side of house	15' 0"	9" sq.	40	9"	B.
"Turbos 1 and 2." 350. 1916.	Oil. 4-cylinder vertical semi-Diesel. 200 B.H.P. 250 r.p.m.	4-stage rotary exhauster. 8000 cu. ft. air per min. at 9" Hg. at 2700 r.p.m.	Oil-cooled double helical speed increasing gear. Ratio 10 to 1	—	1	150	600	2	8	45' tapers 18" to 12"	40' tapers 12" to 8"	8" bent	6 Avery autos at 250 lb. placed centrally.	23' 4"	8" round	Exhauster speed 2400	7"	C.
"Dolphins Millwall." 4 towers. 1921.§	D.C. motor. 220 E.H.P. at 540 r.p.m. Voltage 460	3-stage rotary exhauster. 6000 cu. ft. air per min. at 11" Hg. at 3500 r.p.m.	Oil-cooled double helical speed increasing gear. Ratio 6½ to 1	—	1	2000	200	2	7	30' tapers 10" to 7"	50' of 7" parallel	7" taper	10 hand lever. All on one side between Dolphin and quay.†	27' 0"	6" round	Exhauster speed 3250	10"	C.

* The "pump constant" gives the volume of air per revolution displaced by the total number of pumps fitted. Clearances and tail-rods, areas, &c., have not been deducted therefrom. † Shortly to be replaced by Avery automatic scales at 250 lb. ‡ Has been reduced to size given by internal baffling. § All four towers are similar; the particulars given are for one tower only. The date 1921 is for reconstruction. Plant was built in 1903. ‖ Approximate only from over-all dimensions.

Horizontal drag is that length of horizontal or partially horizontal pipe line which is carried permanently attached to the canister.

Vertical lift is that length of vertical piping which has normally to be added to the permanent vertical pipe line carried in order to work a ship.



GENERAL ARRANGEMENT OF DOLPHIN GRAIN DISCHARGING PLANT

Details of Design of Plant: Group C.

The Hull.—Reduced to 60ft. long by 30ft. wide at deck level; depth 11ft. 6in., and about 6ft. 8in. loaded draught; sides of pontoon raked and made swim-ended fore and aft, and provided with budget plates for ease of towing.

The Engine.—The obvious disadvantages of a steam plant for intermittent working are the space occupied by, maintenance of, and attendance on the multi-tubular marine type boiler—whether the machine be working grain or idle; and the cost of loading, stowing and handling the coal therefor.

A 200 horse-power four-cylinder vertical semi-Diesel oil engine made by Messrs. Vickers-Petters was fitted, and is of their standard VJ 4 type. Normal running speed is 250 revolutions per minute, but an auxiliary hand-operated governor is provided to enable the engineer to vary this within limits for the different classes of grain to be worked. Fuel is Anglo-American or other approved gas oil of a specific gravity of about 0.86 and flash point of 150 deg. Fah.; fuel consumption is ½ pint per brake horse-power hour, and about 3000 gallons is carried in two cylindrical tanks disposed inside and one on each side of the pontoon. Starting up is by compressed air, blow lamp, ignition tube, &c., and can be effected in less than three minutes from cold. A large fly-wheel is fitted to minimise cyclical variation. Cooling is by circulation of dock water to the engine jackets; there is no water injection to the cylinders. The engine exhausts are carried about 30ft. above deck level, and are provided with silencers, water sprays, &c., also hand-holes to facilitate periodical cleaning.

The Air-exhausting Plant.—On account of the large volume of air to be dealt with at low pressure, any type of reciprocating exhauster, whether horizontal or vertical, must be fitted with a number of inlet and exhaust valves of large area; or a greater number of valves of small area. The Port Authority has no plant to date fitted with vertical reciprocating exhausters; but there is no doubt that the

maintenance of these valves is a big item for the horizontal type. Dust gets between the valves and their leather, rubber or other form of seating, which is rapidly eaten away, with a consequent drop in efficiency, and stoppage of the plant for renewals; this also applies to the cylinders themselves with the piston and/or junk rings therein. For these and other reasons it was decided to abandon reciprocating and fit rotary exhausters. The exhauster fitted is of the "Rateau" pattern, four-stage single flow, made by Messrs. Fraser and Chalmers, of Erith, and was designed to be capable of dealing with a quantity of free air equivalent to 8500 cubic feet per minute maintained at a vacuum of 9in. of mercury below atmospheric pressure at a temperature of 60 deg. Fah. when running at 2700 revolutions per minute. Force lubrication is provided for all main bearings. The joint in the casing is horizontal, and tackles, &c., are fitted to facilitate inspection of the rotor impellers. The exhaust is carried about 30ft. above deck level, is placed remote from the engine exhaust, and is provided with a form of flap valve to eliminate any effects of back pressure due to surging. No maintenance or other charges have been incurred with this portion of the plant, which has been at work since 1916; and, due to the large and efficient dust cyclone fitted, no appreciable wear is visible on the rotor impellers.

The oil engine is connected to the exhauster by double helical oil-cooled gears made by David Brown, of Huddersfield. The ratio of speed increase is about 10 to 1. Flexible couplings made by Wellman, Bibby Company, Limited, of London, are interposed between the oil engine and the gears, and the gears and the exhauster. The reduction on the cost of running the elevator as a whole effected by fitting the above described type of main power plant may be seen from the tables of cost referred to later.

Design of Superstructure.—The general lay-out of this portion of the plant can be seen from drawing* which has been published in the technical Press, and was built by Henry Simon, Limited, of Manchester. The pipe crane and pipe line is arranged for slewing for either "side on" or "end on" working; also for luffing for rapidity in getting in and out of a ship's hold and for variations in the beam and freeboard thereof. The principle of the auxiliary elevator from grain canister to grain hopper is retained in order to ensure stability on the relatively small hull. The whole of the pipe boom complete is carried attached to the elevator, and is provided with permanent vertical telescopic portions to minimise the length of additional pipe required to work a ship, and the supplemental labour charges incidental thereto as previously referred to. The operation of the pipe lines and extra lengths of pipe is effected by motor-driven winches, &c., attached to the pipe crane, and is controlled from a driver's cabin thereon. These motors are supplied from an auxiliary generating set of the oil engine-cum-dynamo type. This auxiliary set also supplies power for the bucket elevator motor, the grain tipper, the dust cyclone wheel valve and worm, the deck capstan, the air compressor, bilge pump and fan, fuel pump, &c., and also for the lighting throughout the vessel.

* The Engineer, February 28th, 1919.

Conversion of Power Plant at Millwall Docks.

A full description of the arrangement of the pneumatic intake plant at the Dolphins central granary, Millwall Docks, prior to conversion, will be found in the papers referred to in the bibliography. Briefly, it consisted of a wooden staging or dolphin standing at about 50ft. from the central granary quay, and being about 350ft. long, 25ft. wide, and 14ft. above Trinity high-water level. The superstructure on the deck of this dolphin consists of four pneumatic grain-handling towers of the Group A type, complete with necessary grain pipes, hand-lever scales, &c. This superstructure has been or is only to be altered in two respects:—(*a*) Dust cyclones, wheel valves and worm conveyors of Group C type have been added for the better protection of the rotary exhausters to be described hereafter. (*b*) The hand-lever scales are being replaced by Avery automatic scales.

The power plant consisted of boilers, steam engines and horizontal reciprocating exhausters of the Group A type, housed beneath the deck of the dolphin, and it is the whole of this plant which has been replaced by four sets of Group C type power plant operated by electric motors instead of oil engines. The four sets (one per grain tower) are arranged in pairs, each pair being enclosed in an engine-house standing upon the deck of the dolphin; it has therefore been possible to complete the erection of the new plant before discarding the old, thereby keeping the plant in commission throughout. The general lay-out of the new plant is shown in Fig. 1; each of the four sets is identical, and a brief description of one set is given below.

Motor-driven Rotary Exhauster Sets.—These were constructed by Messrs. Reavell, of Ipswich. Each set consists of a motor with the necessary starter, &c., connected through a flexible coupling to oil-cooled speed-increasing gear, which is again connected through a flexible coupling to a high-speed rotary exhauster; the whole of the unit is carried on one common bed-plate.

The Motor is of the open protected type, compound-wound, and fitted with interpoles. To work on direct-current at 460 volts; shunt regulation of speed from about 360 revolutions per minute to 600 revolutions per minute; horse-power, 200.

Speed-increasing Gear.—Both flexible couplings are of the pin and rubber bush type. The gear is of the double helical type and is oil-cooled, the oil being circulated to gears and bearing by pump-driven through worm gear off the main low-speed shaft, a magnetic oil strainer and cooler being provided. The oil pressure is between 6 lb. and 10 lb. per square inch, and a gauge and relief valves are fitted. Water for the oil cooler is provided by a small rotary pump driven by belt from the low-speed coupling. The ratio of speed increase is about 6½ to 1, and a tachometer is fitted.

The Exhauster.—The rotor consists of three impellers mounted on a rigid shaft revolving in roller bearings; there is a thrust bearing and two main roller bearings, which are supplied by the gear-case oiling system, and return their oil to the common sump. Attenuated air is led from the cyclone to the exhauster inlet and is discharged at or slightly above atmospheric pressure on the outlet, a butterfly valve being fitted in the inlet or suction opening. The suction side is connected to a 30in. mercury gauge and an automatic dial type vacuum recorder; and the delivery side is connected to a 30in. water gauge. The duty of the exhauster is to aspire 6000 cubic feet of attenuated air at a pressure of 11in. of vacuum (Hg.), and to compress this to atmospheric pressure for delivery. These conditions are fulfilled when the motor speed is about 540 revolutions per minute and the exhauster speed about 3500 revolutions per minute. If the motor speed be raised to 600 revolutions per minute, the exhauster speed becomes 3900 revolutions per minute, and a maximum vacuum of 14in. Hg. may be obtained.

Switchgear.—Elaborate switchgear is fitted with the object of preventing the motor being subjected to heavy overloads either during starting up or under running conditions. This switchgear is not vital to the plant, and will not here be described.

Table II.—*Costs of Working of Machines. Year 1919–20.**

Name and group.	Working. Tons.	Hours.	Tons per hour.	Fuel consumption. Electricity units.	Oil, gals.	Coal, tons.	Tons grain per unit.	Fuel consumption. Tons grain per gal.	Tons grain per ton.	Costs in pence per ton of grain. Wages.	Fuel and stores.	Maintenance.	Total cost (pence) per ton of grain raised.†	Remarks.
"Rapid" A	88,174	1183	75	—	—	950	—	—	93	4.27	5.68	3.22	13.17	Steam. Two-tower machine.
"Mark Lane 2" A	60,468	1027	59	—	—	460	—	—	131	4.33	3.82	4.33*	12.48	Steam. Single-tower machine. Deduct 1d. per ton from maintenance for unusually large boiler repairs.*
"Mark Lane 3" A	76,734	1424	54	—	—	620	—	—	123	3.82	3.54	1.48*	8.84	Steam. Two-tower machine. Cost of maintenance unusually low, as machine only had three overhauls in year instead of four.*
"Chicago" B	72,292	1179	61	—	—	601	—	—	120	4.03	4.41	2.27	10.71	Steam. Single-tower machine.
"New York" B	56,683	870	65	—	—	446	—	—	127	5.56‡	3.80	3.47	12.83	Steam. Single-tower machine.
"Turbo 1" C	69,154	1214	57	—	11,902	—	—	5.8	—	3.09	2.37	1.44	6.90	Oil. Single-tower machine.
Bucket elevator "Mitchell"	47,046	768	61	—	—	30§	—	—	1585	3.33	0.55	2.96	6.84	Bucket elevator. Slewing and luffing cantilever type. Suction gas.
Bucket elevator. Nos. 1 to 8 elevators and two steam barges	111,911	2215	51	—	—	258	—	—	436	5.97	1.67	5.62	13.26	Steam. Elevators and conveyors hand rigged.
Bucket elevators A, B, C, D	76,616	1444	53	29,740	—	—	2.58	—	—	3.76	0.69	5.05	9.50	Motors. Elevators and conveyors hand rigged.

* The above are engineering division working costs only, exclusive of general charges, interest and depreciation. † Deductions as shown in "Remarks" column; being cost per ton of abnormal or unusual charges on ordinary maintenance; should be made in order to arrive at a normal total cost per ton for the year. ‡ It will be noted that, generally speaking, wherever the cost in pence per ton for *Wages* is high the tonnage handled for the year is low. § To nearest ton.

Table III.—*Average Test Results for Group C Machines.*

Machine.	Length of pipe line in feet.	Quarters of grain.†	Net time in hours.	Main engine. Fuel consumed in pints.	Quarters per hour.	Tons of grain per hour.*‖	Pints of fuel per hour.	Pints ÷ 0.6 = B.H.P.‡	B.H.P. per ton per hour.	Average. Results for ten tests on each machine in 11 different ships.‖
Turbo 1	72	2569	8	584	321	71	73	122	1.72	Engine speed, 250 r.p.m. Vacuum, 7".
	85	2933	9	720	326	72	80	133	1.85	Quarters of grain per hour, 304. Tons per hour, 67.
	90	1179	3½	270	314	70	72	120	1.72	Pints of fuel per hour, 76. Length of pipe line, 83'.
	90	1700	6½	487	263	58	75	125	2.16	B.H.P. = 127. B.H.P. per ton per hour = 1.9.
Turbo 2	70	2767	7	483	395	87	69	115	1.35	Engine speed, 250 r.p.m. Vacuum, 7".
	80	3000	9	634	333	74	70½	117	1.59	Quarters of grain per hour, 325. Tons per hour, 72.
	90	1532	5	370	306	68	74	123	1.81	Pints of fuel per hour, 73. Length of pipe line, 83'.
	104	1383	5½	423	251	56	77	128	2.28	B.H.P. = 121. B.H.P. per ton per hour = 1.68.

Dolphins Millwall. Cost and test data, if available, will be given during discussion of paper.
* Wheat assumed at 4.52 quarters per ton. † All results are for wheat discharge as weighed out *through* scales.
‡ Fuel consumption assumed at 0.6 pint per B.H.P.-hour. § Tons per hour from Table II. = 57. ‖ Average for the two machines over the twenty tests = 1.78 B.H.P. per ton of grain per hour.

Operation of Plant.

The conversion has only been effected for a few weeks, but during this period the plant has run well. For this reason it has not been possible to include any figures for the plant under Table II.; it is, however, certain that the engineering charges will be appreciably reduced.

Engineering and Bulk Grain Costs.

Cost for the floating pneumatic elevators apart from establishment and other special charges may be regarded as being made up of engineering and bulk grain costs. Engineering costs refer to the working and maintenance of the machines themselves and the engine-room crew therefor, and will be found set out in Table II. Bulk grain charges are for extra labour employed on or about the machines in connection with the actual discharge of grain, and include such items as wages for grain superintendents and their staffs, foremen, ship workers, deck crews, gangs in the ship's hold and aboard the elevator itself, weighers for operating the scales, &c. From the table it will be noted that the Group C or new machines show to advantage in the matter of engineering costs.

Test Results and Remarks Thereon.

Certain "chute loose" tests on Group C machines are set out in the table of tests. In considering these results, it should be noted that they are not a measure of the maximum rate at which the intake or pneumatic portion of the machine would lift grain; but only of the limited rate at which weighers deliver it to craft; and further that any delays caused by faulty operation of the grain pipes in the ship's hold, or the craft receiving delivery are included therein. The rates of discharge given in the table of costs have been reproduced in Table III. to show that these and similar delays have a very appreciable effect on the performance of the machine.

In the *Railway Age* (New York) of November 12th was an article on the need of the railways of Central Europe for fuel and equipment, wherein was a very gratifying reference to Sir Francis H. Dent, the late general manager of the South-Eastern and Chatham Railway, who is the head of the Commission dealing with the allocation of rolling stock. It says "Sir Francis Dent probably has had one of the most trying assignments made by the Peace Conference."

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

ENGINEERS AS ADMINISTRATORS.

Sir,—Surely your leading article of December 16th is itself proof that the more engineers in positions of high administrative authority in this world the better, and certainly in all such involving the manipulation, manufacture, and distribution by sale of engineering plant.

Such administrators to be drawn from the ranks of men who in their youth have undergone sound "bench" training as useful fitters, also with practical experience in all weathers of forge and foundry work, as opposed to the present-day university dilettantism, so apt to consider the British workman in terms of cooliedom or, worse still, political flattery, thus directly creating the use of the term "labour troubles."

The magnificent address to the Institution of Locomotive Engineers by Colonel Kitson Clarke, so sympathetically noticed in your columns, is exactly antithetic to academic engineering. It must have touched a warmly responsive chord in many young hearts among the older engineering "bloods;" those lucky enough to have heard or read it should also read "No Man's Land," by O. P. I. P., a pamphlet emanating from the same authoritative source. In these speaks the true and only possible "labour leadership."

The field of vision of those who complain that administrative duty debars them from giving further scope to mechanical aptitude does not embrace the full engineering horizon which is not, after the manner of what a lay general manager of a railway once publicly stated locomotive working to be, viz., "A mere matter of measuring coal, oil and waste," but glorious opportunity for enhancing the general good. An engineer, realising this, himself the real steward of his shops, having in his youth "drawn a straight file" for pay with the best, is most capable of and best fitted for blending humanity with rigid principle in all matters concerning the British workman, politicians, and academic pundits notwithstanding.

Time sheets, account books, and storekeeping are matters for a clericalism sternly subordinated to managing engineerships. I can visualise an engineering concern staffed to turn out necessary output at highest quality, contentedly and happily, on a *daywork* basis, considerably eliminating time books and clerks and certainly dispensing with that horrible spawn of academic hysteria wedded to the prevalent petty, policing, "pussyfoot" spirit—the "time recorder;" a vision encouraged by your previous leading article on "Tataism," and your welcome correspondent on "Efficienc " in the same issue of THE ENGINEER, both of which articl many others as well as myself must have read with sympati y and joy, especially your remarks as to the shop limit of 700 men.

Engineering has no "polit.cs," but above such "professions" as "Law," "Medicine," and "The Church," its true understanding and use is the tap root of future policy, domestic and world-wide, and I am convinced that from what one knows of law courts the world over, 80 per cent. of the cases appearing there could be right morally settled by committees of the Institution of Mechanical Engineers in 20 per cent. of the time and at 5 per cent. of the prevailing extortion; or, better still, before a court of divisional locomotive superintendents accustomed, as they are, to controlling inquiries into railway accidents.

The force that drives him to sacrifice his personal convenience to the welfare of the plant committed to his charge, to nurse, as a mother her child, a bearing, an engine, or a foundation, or to make a report, if necessary, truthful to his utter disadvantage, shunning like the plague what good old MacAndrew terms, "To lie like stewards wi' patty pans," is religion enough for the engineer; facility for the exponents of such religion to be introduced rapidly into the administrative world will be a mighty step forward and upward in the process of our evolution, and the thanks of such all over the world are due to you for affording sympathetic ventilation to this subject.

December 18th. CECIL G. HOWSIN.

Sir,—I think that it would be a pity if the leading article on this subject in your last issue should have the effect, on the one hand, of causing any young engineer who aims at an administrative position to think that he need not trouble about the technical science of his business; or, on the other hand, of leading one who has the true scientific spirit to contemn economic science as of little consequence. The importance to the industry and to the nation of securing the best administrators in the coming years is my excuse for offering some thoughts on the subject.

It will be admitted that the final object of engineering industry is economic, and that technical science is one of the means to be used in attaining that object. The man who is ultimately responsible for economic success must have the power to decide all questions which affect it, and he certainly cannot have that power unless he has had the engineering training which will enable him to weigh justly the technical problems put before him by specialists. These problems, however, cannot be solved purely by considerations of technique, but matters must be taken into account which the man engrossed in technics alone has not had the time or the inclination to study.

It may be, as you say, that the engineering training of the administrator is little used, if by little is meant that the intervals of time between the occasions of its active use may be considerable; but surely it is not the frequency with which the knowledge is used that matters, but rather the importance of the occasions of use; I do not agree that in this sense the word "little" is appropriate. Also, the fact that the knowledge is in the mind of the chief, ready to be used, is of great importance in stimulating the minds of his more purely technical colleagues.

To leave administration to some person without technical training, no matter how great his abilities, would in most cases result in failure, and dual control is not often a success. The conditions of industry in the time of Boulton and Watt are not comparable with the conditions existing to-day, and we of this generation have problems to solve of which Boulton and Watt never dreamed.

I think that you put the work of the administrator on rather a low plane; he does not mainly busy himself with account books and time sheets any more than he busies himself with routine calculations of stress or the microscopic examination of a defective forging; but he must be able, of his own knowledge, to appreciate the data put before him in any of these directions.

I also demur to the view expressed that mass production is making towards the destruction of the science of mechanical engineering. I hold, on the contrary, that this particular adaptation of means to ends demands stricter scientific methods in the administration than the older methods, if success is to be reached, and it presents deeply interesting problems which can only be solved by the application of both engineering and economic science. RICHARD A. MCLAREN.

Renfrew, December 18th.

LOCOMOTIVES WITH FOUR EXCENTRICS.

Sir,—I note that Mr. Dendy Marshall wishes to withdraw the statement that the Swiftsure was the first locomotive to have four fixed excentrics. In the interests of historical accuracy I should be sorry if his withdrawal is premature, since it cannot be definitely proved that he is wrong, and the particulars given in THE ENGINEER, Vol. 55, page 159, referred to by Mr. Forward, appear to show that he may possibly be correct.

In THE ENGINEER referred to Mr. Alexander Allan illustrated a plan view of the Swiftsure, which shows four excentrics. Mr. Allan further states that the Swiftsure was built in 1834, and not in 1835. If this is the case and Mr. Allan's drawing and dates are correct, the Swiftsure with four excentrics ante-dated Hawthorn's Comet of March, 1835. Wishaw (1840) gave a complete list of the Liverpool and Manchester engines, presumably from the official register of the company, in which 1835 is given as the date of the Swiftsure.

In any case there are several unsatisfactory details in the historical records, as far as they have been handed down to us. Mr. D. K. Clark, on page 10 of "Railway Machinery" (1855), illustrates an engine by Forrester, which, from the wording of the text, is supposed to have been a standard design of this firm. The peculiar valve gear is illustrated on page 21 of the same book, the date given being 1834. In regard to the engine, Mr. Allan, in letters written in 1891, which I have, states that the illustration is far from accurate, and points out that it shows two slide bars, whereas Forrester's engines had four. Further, he states that Forrester's frames enclosed the cylinders, but in the illustration the cylinders enclose the frames. Then he adds: "*the part of the valve gear shown is right.*" (The italics are mine.)

The same illustration of Forrester's engine is shown in Colburn's "Locomotive Engineering" (1871), page 41, a book for the revision and completion of which Mr. D. K. Clark was responsible. Mr. Allan was acquainted with Mr. Clark, who illustrated and described some of Mr. Allan's engines, and some particulars of Mr. Clark's visit to Crewe in connection with the preparation of "Railway Machinery" of 1855, as given by Mr. Allan himself, are quoted in THE ENGINEER, Vol. 55, page 405. It seems a pity that Mr. Allan does not appear to have drawn Mr. Clark's attention to the errors in the illustration on page 10 of "Railway Machinery." Had he done so, and also corrected the statement on page 22 of the same book that Messrs. Hawthorn made the first application of four excentrics, these errors, if such they are, would not have been repeated in Colburn's book of 1871. It was only in 1883 that Mr. Allan drew attention to the use of four excentrics by Forrester, and at a still later date pointed out that D. K. Clark's illustration was not correct.

Referring again to THE ENGINEER, Vol. 55, page 160, we find on the authority of Mr. Allan that "in 1848, to simplify the valve gear, Forrester suggested a modification of the Carmichael gear by shortening the excentric rods . . . and to work the valve on each side with one fixed excentric. Mr. Allan made the drawings and worked out this suggestion nearly as seen in D. K. Clark, page 21."

It is strange to see from this that Forrester, after using four fixed excentries, should wish to get out a design in which a return was made to two only, and stranger still that this suggestion should have been made in 1848, when nearly all locomotives were being constructed with link motion. It is very probable that the date 1848 was intended to have been written 1838; but in any case, it appears that Forrester intended to use a single excentric on each side in spite of the excellent reasons given by Mr. Allan for the use of double excentrics in the previous engines of the "Swiftsure" type. Such a statement makes one wonder whether the latter engines really had four excentrics when they first appeared.

It seems certain that the illustration on page 10 of "Railway Machinery" does not represent the Swiftsure, which was a four-wheeled engine, subsequently altered in 1836 or 1837 to a six-wheeled engine. If Mr. Allan is correct, the engine illustrated cannot have been built before 1840, since in one of his letters in my possession he states that it was only in 1840 that he himself brought forward the form of crosshead shown with two slide bars. Most of Forrester's engines can be traced, and if the engine in question existed otherwise than on the drawing board it was possibly one of three, two of which went to Germany before the end of 1842, and the other was an engine built in 1842 or 1843 which ran on the South-Eastern Railway. Nothing is known of these engines except that the one for the South-Eastern had 5ft. single driving wheels and 14in. by 18in. cylinders. But if this is the correct explanation, it would appear that Forrester, after using four excentrics in 1834–5, had made the retrograde step of using two only in his engines built several years later. E. L. AHRONS.

December 19th.

Sir,—Before William T. James, of New York, had built his three-wheeled steam road carriage in 1829, with four-excentric reversing gear, Robert Stephenson and Co. had built the Lancashire Witch for the Bolton and Leigh Railway in 1828, and it may surprise a great many of your readers to know that an independent cut-off reversing expansion gear was used on that engine.

The expansion gear, which was also the regulator gear, operated in such a manner as to control lead and cut-off perfectly for both forward and backward motion, and could be set for either forward or backward running while the engine was at rest, but the main slide valves could only be set for forward or backward running by moving the whole engine to make contact between the loose excentries and their driving sectors, as was usual on all engines at that time.

In 1829 Robert Stephenson and Co. built for the Stockton and Darlington Railway a six-coupled engine, Rocket No. 7, which also was fitted with an independent cut-off reversing expansion gear. This gear formed a part of the main slide valve gear and both gears could be set for forward or backward running while the engine was at rest.

The original drawings of both these engines are in South Kensington Museum, and it may afford many of your readers considerable satisfaction to work out the action and details of these gears for themselves, especially as they have never been illustrated or described in any history of the locomotive.

Glasgow, December 17th. JAS. DUNLOP.

TANKS AND CHAIN-TRACK ARTILLERY.

Sir,—May I ask you to be kind enough to correct a disagreement between Fig. 32 and the text relating to it at the foot of the right-hand column on page 659? This should read "the point B of the frame becomes displaced to B^1; the chain-track remains in gear with the ground, while the point A, nearer the front, climbs to A^1." L. A. LEGROS.

Acton, December 16th.

SLAG IN CONCRETE.

Sir,—At intervals there are statements in the Press that cement concrete with slag aggregate has failed after long years of apparently sound life. It is difficult to find instances. Might I invite your readers to give particulars of such failures that have come to their notice? If it be desired to give the information in confidence, it might be sent to me direct.

H. O. WELLER,
Director of Building Research.

16 and 18, Old Queen-street, Westminster,
December 19th.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

We are informed that the Ingersoll-Rand Company, Limited, has been appointed sole agent in the British Isles for the Swedish Sandviken drill steel.

HOLLINGS AND GUEST, Limited, of Thimble Mill-lane, Birmingham, ask us to state that they have recently appointed Mr. D. Lamdale Frew, of 45, Hope-street, Glasgow, as their sole agent for Scotland.

TEXACO PETROLEUM PRODUCTS COMPANY, Limited, the chief offices of which are at Imperial House, 15, 17 and 19, Kingsway, London, W.C. 2, asks us to announce that as from January 1st, 1922, its title will be changed to the Texas Company, Limited.

We are advised that Messrs. Bostock and Bramley, Netherton, Huddersfield, have combined interests with Joshua Buckton and Co., Limited, of Leeds, for the manufacture of all types of gearing to Messrs. Bostock and Bramley's designs and specifications.

GEORGE JONES, Limited, of Lionel-street Foundry, Birmingham, informs us that in consequence of the death, on the 22nd ult., of Mr. Alfred Turner, who was for many years a director, manager and secretary of the company, Mr. H. Knight and Mr. T. C. Whitehouse have been appointed as joint managers, and Mr. Wm. Barron has been made secretary.

MR. ERIC POTTER, of Lonsdale Chambers, 27, Chancery-lane, London, W.C. 2, asks us to state that he has removed his Midland offices from Temple Buildings, Albert-street, Nottingham, to Commerce Chambers (Elite Theatre), Parliament-street, Nottingham. His London address will remain unchanged. The change of address also refers to Messrs. E. Potter and Co., under which style his consulting and supervising business is carried on.

We have been asked to announce the termination on December 31st, 1921, of the working arrangement between the "Turnover" Filter Company and J. Blakeborough and Sons, Limited. The latter firm, which has lately joined hands with George Kent, Limited, has decided to cease altogether the manufacture of water filters, and it is therefore requested that all future inquiries for filters should be addressed direct to the "Turnover" Filter Company, 101, Bridge-end, Belfast.

LAUNCHES AND TRIAL TRIPS.

RUNIC; White Star liner; dimensions, 550ft. by 63ft. by 44ft.; gross tonnage, 12,500. Engines, two sets quadruple-expansion engines; re-conditioned by Harland and Wolff recently.

DABCHICK; 600-ton hopper barge; built by Lobnitz and Co., Limited, to the order of Bombay Port Trust, Bombay. Sailed for destination on October 30th; trial trip recently.

CITY OF TOKIO; geared turbine steamer; built by Craig, Taylor and Co., Limited, to the order of Sir John R. Ellerman, Bart., for Ellerman Lines, Limited dimensions, 461ft. 3in. by 58ft. 10½in. by 34ft. 3in. Engines, single-screw double-geared turbines of Parsons impulse reaction type, pressure 220 lb.; constructed by Palmers Shipbuilding and Iron Company, Limited; Howden's forced draught fitted; trial trip recently.

PARISIANA; built by Irvine's Shipbuilding and Dry Dock Company, Limited, to the order of Furness, Withy and Co.; dimensions, 433ft. 6in. by 55ft. by 30ft. 6in.; to carry 9750 tons deadweight. Engines, double-reduction geared turbines; constructed by Richardsons, Westgarth and Co., Limited; trial trip recently.

KARONGA; geared turbine steamer; built by Wm. Gray and Co. (1918), Limited, to the order of Ellerman Bucknall Line, Limited; dimensions, 430ft. 9in. by 57ft. 3in. by 32ft. 10in.; to carry 10,600 tons deadweight. Engines, one high-pressure impulse type and one low-pressure reaction type turbine, pressure 225 lb.; constructed by the builders; Howden's forced draught fitted; trial trip, Wednesday, November 23rd.

SOCIETY OF ENGINEERS.—At the annual general meeting of the Society of Engineers, held on December 12th, the following premiums for papers read during 1921 were awarded:—The President's Gold Medal to Mr. G. O. Case for his paper on "The Winning of Tidal Lands in British Guiana"; the Bessemer Premium to Mr. R. W. A. Brewer for his paper, "Some Modern Engineering Practice in America"; the Nursey Premium to Mr. Alfred S. E. Ackermann for his paper on "The Physical Properties of Clay" (third paper); the Society's Premium to Mr. W. M. Beckett for his paper on "Northwich Sewerage and Sewage Disposal Works"; and the Geen Premium (open only to members of associated societies) to Mr. C. F. Moore, of the Crystal Palace Engineering Society, for his paper on "The Locomotives of the London and North-Western Railway."

DEW RESERVOIRS.—We have received from Mr. S. B. Russell, of 10, Gray's Inn-square, London, W.C. 1, a pamphlet in which he advocates the use of dew reservoirs for providing supplies of potable water in districts where other sources are inconvenient or absent. A sketch shows that a shallow excavation is made and lined with heat insulating material to form the reservoir. The roof is also insulated, and has a condensing upper face on which the dew is deposited and runs down into the reservoir. A corrugated iron fence and a hedge are set round the site to protect it from the wind. It is said that a condenser of 100 square yards area will collect 24,000 gallons of rain and dew in the Eastern counties in the course of a year, and with a storage capacity of 12,000 gallons would furnish an average daily supply of 120 gallons during the hot summer months and 50 gallons a day for the remainder of the year.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Business in Steel.

THE sudden rise in the American exchange has had the result of reopening steel business. Offers of American billets have been received at prices which may compete with native prices. The recent rise in English values of semi-finished steel has given the Continent an opening, billets being on offer at £5 17s. 6d. at Antwerp, as compared with the home price of about £8. English makers were prompt to take advantage of the disappearance of foreign competition, but it is now believed that home quotations will have to be reduced. Belgian joists and rails are being quoted £9 10s. delivered here. Among other lots on offer is some derelict war material, consisting of rails, bars, &c. Some of the former are being offered at as low as £5 17s. 6d. Antwerp. The steel makers are doing rather more work at recent prices, but all trades dependent on shipbuilding suffer from the poor demand in that department. The slow progress being made in the steel department is shown by the official statistics published by the National Federation of Iron and Steel Manufacturers. These show a total steel production in the counties of Staffordshire, Shropshire, Worcester, and Warwick of 46,300 tons in the month of November, an increase of 6 per cent. on the previous month, which increase compares with an average of 10 per cent. for the whole of the kingdom. It represents, however, a reduction of 42 per cent. as compared with September of last year. The figures indicate the very slow progress made by the trade, although the prices accepted for finished steel are notoriously unprofitable. In order to meet the new foreign competition it is stated that this week English steel makers have offered to supply billets at £7 f.o.r., a figure which should make the American steel unattractive. As English steel works will now sell finished steel bars at £10 10s., re-rollers are practically unable to compete at the present price of billets. This has increased the dullness in the Black Country, where a number of ironworks have for several months utilised their mills for the re-rolling of steel.

Manufactured Iron.

The local ironworks are very short of work. The manufacturers have done their best to find their men employment before Christmas, and orders have been accepted without any idea of making a profit. The best bar houses are feeling the dullness in the shipbuilding trade and there is none too much business about just now. Prices of best bar iron remain at £16. In Staffordshire unmarked bars the official declaration of £13 has very little practical application. Unassociated mills are accepting anything down to £12, and members of the Association have to compete. Belgian bars are firming up again after their recent relapse, but they can be bought at £9 10s. delivered here. The circumstances of the market are against an expansion of business with the Continent. Another feature which is becoming more prominent in the bar iron trade is the disregard of standard extras. Many sellers are exercising a free hand in this as well as in the matter of price. The standard list of extras as a rule is rigidly adhered to, but it is now being drastically cut. There is still a fair demand for galvanised sheets and makers are keenly competing for orders. Prices are easier at £17 to £18 for 24-gauge sheets in bundles f.o.b. Makers can now purchase their sheet bars down to £7 15s. ranging to £8.

Pig Iron.

There is a slightly better demand for foundry pig iron, but prices remain weak. Northamptonshire foundry iron has been sold at as low as £4 7s. 6d. at the furnaces and forge iron, for which there is an exceedingly small demand, proportionately lower. Derbyshire No. 3 is quoted at about £4 17s. 6d. There is very little business passing. It is noticeable that there is now a gradual improvement in the output of pig iron, and at the end of October there were eighty-two blast-furnaces in operation, compared with sixty-eight at the end of September. Continental competition in this department is still felt, but it is good to note that there has been a decided decline in our purchases of forge and foundry irons from the Continent during the past three months. Imports of basic iron have, however, jumped up again. This is a very disturbing feature and goes a long way to explain the difficulty experienced in getting the British blast-furnaces into action again. Furnace owners hereabouts state that with coke at 22s. 6d. they are working at a loss. Great interest is taken in the announcement by the railways with regard to the rates to be quoted in the New Year. Apparently some business has been kept back by consumers in the hope that reduced rates will bring a corresponding fall in selling prices. But several of the smelters have warned their customers that these reductions have already been discounted in the low prices now quoted. North Staffordshire makers are insisting on £5 10s., but are doing very little business, being well undersold by Northamptonshire and Derbyshire irons.

Nuneaton Pit Dispute.

The dispute at Stanley Brothers' Nuneaton Colliery, as reported in my letter last week, caused by the men refusing to accept a 10 per cent. wage reduction, has been settled, and work at the pit has been resumed. It is understood the mutual arrangement arrived at provides that for three months an amount equal to 10 per cent. reduction shall remain to assist the firm. If at the end of that time it is found the colliery has paid, the men will receive it; if not, they will forfeit it.

Halesowen Mine Flooded.

The Witley Colliery, Halesowen, has at last had to be abandoned by the management. This is one of the pits which were flooded out during the coal strike, but an effort was made to re-start it. The pumps were able for a time to reduce the water sufficiently to enable work to proceed, but the inrush has become so great—due in all probability to the flooding of the neighbouring pit at New Hawne—that the plant is unable to cope with it, and operations have ceased. About 100 miners have been thrown idle, and the clay miners and brickmakers will also be affected.

Trade Boards.

The strong opposition to the Trade Boards in Midland engineering circles is shown by the evidence recently given by Mr. Alexander Ramsay, chairman of the Management Board of the Birmingham and Wolverhampton districts of the Engineering and the National Employers' Federation, before the special committee. It was a matter of common knowledge in the Midlands, he said, that workpeople who were protected by Trade Boards did not join trade unions, and as Trade Boards extended the authority of the trades unions over the workers would correspondingly decrease. Having pointed out most clearly the confusion that Trade Boards had led to, he said they should not attempt to define wages for operations. They should concern themselves only with a minimum wage for the lowest grade of worker in an occupation, and allow the ordinary economic forces to determine the wages of skill and merit.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER, Thursday.

Iron, Steel, and Metals.

So far as iron and steel are concerned there is no sign of any approaching improvement in the general condition of trade, at least none that is visible from Manchester. Of course, one cannot expect to see any activity in business this week; things would be quiet no matter how good were the prospects for next year; but it seems inevitable that the struggle to get prices down will continue yet for some months. In many departments of the iron and metal trades the selling prices are already below the costs of production; but this fact has no influence on the mind of the buyer, who still persists in looking for lower prices. That business can go on very long under such conditions is impossible, but relief must come from lower manufacturing costs and not from higher prices. Manufacturers would do well, therefore, to direct all their energies to the reduction of costs and cease to rely upon any permanent improvement in selling prices. The world is poor and must be provided with goods at prices suitable to its poverty. Both wages and profits will have to be on a more modest scale.

Metals.

The opinion in the copper market seems to be rather more favourable than it was. It is one of the few markets in which prices—at any rate for standard and refined ingot copper—have been low for nearly a year, and this is a time quite long enough to produce a feeling that they cannot well go lower. It is not clear yet that the suitable moment for buying copper has actually arrived. The consumption in all European countries, except Germany, is well below the normal, and it is necessary that this general consumption should be in a better state before a serious advance should take place; but the accumulated stocks in America are being reduced, and although it has been suggested that some of the idle producers there might start again, one does not hear that they are doing so, and it is doubtful whether American producers will start until there is less risk of spoiling the prospects of the market. The rise in the American price has been considerable, and whereas not so long ago it was difficult to find buyers at 12 cents per pound, recently a good business has occurred up to 14 cents. This is an advance equal to about £10 per ton, but it has been partially hidden from us by the rise in the exchange. Experts believe that this alteration in the sterling value of the American dollar has now gone far enough, and if there should be a reaction it would tell sharply in the copper market. The consumer of copper here seems to have a safe course before him by buying his forward requirements in best select and selling standard against it; but if he has the necessary courage one would not now dissuade him from covering requirements for a year ahead and omitting the corresponding selling of standard. There has been a slight reduction in the official prices for copper sheets and bottoms, and it is probable that further reductions in manufactured copper and brass will follow; but this is not of any marked significance, because if raw copper advanced by £10, manufactured copper and brass goods ought still to be cheaper than they are at present. Tin has continued to be a very firm market, but many people in the trade are beginning to think that the advance has now gone far enough, or at any rate as far as can be justified by the condition of demand and the state of the stocks. After a rise of about £20 per ton there may be some taking of profits, which will check the market a little. The market for lead has kept very firm, and there is no sign yet of any weakening. Germany is an anxious buyer of the metal, and this may be because she does not now get lead from Silesia. The European market is practically still without the bulk of the Australian output, and it may be that stringency will continue until Australia resumes her proper place amongst the world's suppliers of the metal. Spelter has been a stronger market, and it is possible that the long depression in this metal is at last coming to an end.

Pig Iron.

The position in the pig iron market remains very unsatisfactory, and it seems almost impossible to get any clear idea of what is going to happen. The outstanding fact is that not one third of the possible production is now being made, and, moreover, this small proportion cannot be sold at a profit. What will have to be done to enable all the furnaces to get to work and to find a profitable market is a question which is at present insoluble; but one cannot believe that the market price can rise until it is solved. There seems to be a belief in some districts, notably in Cleveland, that a revival will show itself early next year, but one cannot help being sceptical on this head. Here, amongst consumers of pig iron, there is a strong opinion that next year the market price will be lower, whatever the actual cost of production may be. There is no business moving at present, unless it be an odd truck or two, and the amount of the reduction of the railway rates is not sufficient to remove the heavy handicap under which the Manchester ironfounder has to work. The foundries here are short of orders and one does not see how they are going to obtain much fresh work until the conditions of transport are again fairly near to the pre-war standard. The cost of pig iron may come down to £4 per ton by next spring, but even if it does the Manchester ironfounder will not get any relative benefit.

Steel.

The official prices for sectional steel are unchanged, but buyers are more dissatisfied with them, because they are constantly hearing of very low prices quoted for export. Thus joists have been quoted f.o.b. at £8, and the buyer here naturally says that if the foreigner or the colonial is to get them at £8, he ought not to be made to pay £10. It is too much to pay for the privilege of being an Englishman.

Scrap.

The trade here in scrap is dead at the moment. The only cheerful news is that steel scrap is going out of the country, and this may relieve the pressure of the accumulated stock. The prices for foundry scrap are uncertain, but probably £4 5s. would be accepted for fairly good qualities. For heavy wrought scrap there is very little demand yet.

Electric Vehicles for Dockside Purposes.

In the course of his paper on "Mechanical Cargo Handling," read by Mr. G. H. Rae before the Liverpool Engineering Society on the 14th inst., the author described the appliances used at West Toxteth Dock by Elder, Dempster and Co. for dealing with cargoes of palm oil, palm oil kernels, cocoa, cotton, &c. The equipment includes electric trucks and tractors and a number of light portable electric cranes. The quantity of electrical energy consumed by the trucks was, the author said, found to be extremely small, and at the rates usually to be obtained it might be said that the cost of current for a vehicle carrying 30-cwt. loads and traversing a distance of 16 miles was only about 1s. for one day. Taking an actual performance in the transport of 34-cwt. loads, it was found that after four hours' running, in which 50 tons had been transported, the B.O.T. units consumed were 1.45. Taking the cost per unit at 4d., the cost worked out at 7d. for four hours. The vehicle on the occasion in question was covering a distance of 230 yards loaded and 230 yards light, and the total number of loaded journeys was thirty, so that the work performed would equal 1.7 ton-miles per hour. Taking into consideration the interest on capital outlay, depreciation, repairs, maintenance, current for charging the battery and drivers' wages, the total cost of operating a truck might be taken at about 3s. 6d. per hour, or the equivalent of the wages to two labourers.

The Engineers' Club.

One of the most enjoyable evening's entertainments which have been held for some time at the Engineers' Club was provided on the 15th, by the chairman, Mr. Bertram Thomas, and friends. Mr. Thomas entertained the committee and officers at dinner and afterwards a delightful concert was given, to which all members and their lady friends were invited. The conspicuous features of the entertainment were the musical and vocal contributions by amateurs.

Manchester Association of Engineers.

About 400 members, accompanied by their ladies, were present on Friday last at a conversazione given by the president, Mr. Fred. J. West, C.B.E., at the Manchester City Art Gallery. After being received by Mr. and Mrs. West, the guests were free to inspect the splendid collection of works of art which are the property of the Manchester Corporation, or to listen to an enjoyable programme of vocal and instrumental music.

The Railway Fusion.

Much satisfaction is felt in this city concerning the decision of the joint board of the London and North-Western and the Lancashire and Yorkshire Railways to make Manchester the headquarters of the northern section of the new joint system extending from Crewe to Carlisle. Although it has not been officially announced, it is reported that Mr. G. Hughes, chief mechanical engineer of the Lancashire and Yorkshire Company at Horwich, has been appointed chief mechanical engineer to both lines.

BARROW-IN-FURNESS, Thursday.

Hematites.

There is still greater quietness to report this week in the hematite pig iron trade of North Lancashire and Cumberland. The demand has fallen away very considerably on local as well as general home account, and the Millom and Askham Company has put out of operation its furnace at the Millom works, which are now entirely idle. On Friday the two furnaces blowing at Barrow will be damped down until January 9th, according to present orders. The position is therefore very unsatisfactory and prospects are poor all round, and it is thought that it will be well into the spring before things look up again. The cut of 10s. is in the direction demanded by users, but further reductions in price are called for. One of the handicaps to smelters is the heavy railway rates. Mr. Myles Kennedy, one of the leading ironmasters and himself a railway director, speaking on Friday last, said that the railway rates were extortionate, and he called for a reduction if the trade of the country is to be revived.

Iron Ore.

The demand for hematite iron ore has fallen away and now very little ore is being raised. The trade is almost wholly a local one. The importations of Spanish ore continue.

Steel.

In the steel trade makers are experiencing a very small demand for all descriptions of metal, and on Friday next the whole of the plant at Barrow will close down for over a fortnight. This week the Siemens departments' rail and hoop mills are operating, as are also the foundries, the latter being engaged on shipbuilding castings, &c., for merchant work.

Fuel.

There is a very small demand for either coal or coke, and with furnaces going out of operation even less fuel is required.

SHEFFIELD.

(From our own Correspondent.)

Two Good Signs.

In the midst of a great deal of distress caused by the heavy numbers of unemployed the Christmas spirit has been endeavouring to develop itself all the week, though for many families in this district, it is to be feared, the season must be the reverse of festive. Most of the steel and engineering works—or those portions of them that continue to be operated—are closing down for about a week, but in very many instances the holiday is to be restricted to a long week-end, while some firms appear uncertain as to when they will re-open. There is a good deal of speculation about prospects for the steel trade, and opinion seems to be as wide as the Poles. It is much easier to hope than to prognosticate, and what I find is that manufacturers are hoping that a better state of industry will develop before the new year has progressed very far. There are certain elements in the situation that justify such an attitude, one of them being the continual fall taking place in raw material prices, and another the very much more reasonable position being taken up by labour in the matter of wages. One does not hear so much to-day of the "Red" claptrap. It was tolerated by certain sections of the men when work was plentiful and wages were good—when, in fact, everything was calm and bright—but the necessity for co-ordinating with Capital in order to win back trade, the absence of which is being so sorely felt, has done more than anything else to bring the extreme gentlemen in the ranks of trade unionists to their senses. Then again, the air is full of inquiries which show less disinclination to be translated into actual business, though the latter still requires an extraordinary degree of skill to "land." I was speaking only this week with the maker of a new type of annealing furnace—about which more detailed reference may be made in a subsequent letter—and he told me that his firm was very busy indeed with inquiries!

Faith in the Future.

It is in faith that the day is not far removed when some of those inquiries will begin materialising that a few of the larger firms here have gone in for very important developments. For example, I believe the new and thoroughly modern steel strip and merchant bar mills at Templeborough are now nearing completion, ready to play their part in the great steel plant, of the continuous type, put down by the United Steel Companies, Limited. It seemed a thousand pities that just as several of that company's developments had been brought to fruition—the installation of the Morgan continuous wire rod rolling mill and the erection of fourteen large open-hearth steel furnaces, &c.—the very trade for which the company sought to cater should have slumped as it did. It was disappointing in the extreme, but the directors should reap the benefit of the first breath of an industrial trade wind. Then, on the other side of the road at Templeborough, are the big developments proceeding at the works of the Sheffield Steel Products, Limited, including installations of open-hearth and electric steel melting furnaces and of large rolling mills, the housings for which I my self saw in place many months ago. When completed these works will be quite wonderful in their way and entirely self-contained, including their own water supply and a fine producer gas plant. The idea is eventually to erect blast-furnaces, so that right from the very raw materials the company will make its own steel and roll it ready for conversion into tools and cutlery on mass production lines. A foundry is also to be provided and batteries of drop stamps. Finally the company has just launched a subsidiary concern, called Sheffield Steel Products (Stores), Limited, the purpose of which is to acquire retail shops in all parts of the country. This part of the scheme is an experiment, the wisdom of which many business men question, but which will be watched with a very great degree of interest. The Park Gate Iron and Steel Company is just getting into operation its new 400-ton metal mixer, into which liquid iron, conveyed from the blast-furnaces in 30-ton ladles, will be treated before being poured into the steel furnaces. The length between the port blocks is 55ft. and the width inside the brickwork is 21ft. 6in. The total weight of the body when fully charged is between 800 and 900 tons, and this is tilted by means of hydraulic cylinders. Another feature at the Park Gate Works is the new 24in. section rolling mill, installed to meet requirements for round bars, squares, and profiles of high-class quality and finish. Rolls up to 26in. diameter for heavier sections can be accommodated. Both the mill and the engine, I believe, have been built from the company's own designs by the Chesterfield engineering concern of Charles Markham and Co. Hadfields, too, are getting into order their new 28in. mill for rolling manganese rails, the work in that case, as I think I have previously mentioned, having been carried through by the Sheffield firm of engineers, the Brightside Foundry and Engineering Company.

Export Outlook Brighter.

One might go on enumerating really important extensions which either have been recently completed or are nearing that stage, and they all go to prove an absolute faith in the future. The peace with which Ireland is now "threatened" should be quite a good thing for the Sheffield district, because for years Ireland has been a very good customer, and with a return to anything like prosperous conditions it is fully expected that that market will prove better than ever. Magnets and motor steels are in much keener demand again, arising out of the mild revival in the motor building industry. So far as exports are concerned there is no recovery yet worth going into ecstasies about, but there seems no doubt that a movement in the right direction is discernible. Cutlery manufacturers are finding the Australian market more active.

Raw Materials.

Regarding raw materials, it is interesting to note that a fresh impetus to the developments which were interrupted by the coal strike and trade slump is probable in North Lincolnshire, and may be manifest particularly by two of the enterprises there, that at Redbourn Hill, controlled by the Thomas interests, and the Appleby Iron and Steel Company, which is, of course, owned by the United Steel Companies, Limited. North Lincolnshire has been experiencing some terribly lean years since hostilities ceased, though it is, as a matter of fact, a veritable land of promise and should now very soon reflect the improvement in the tin-plate industry of South Wales. For a long period no iron furnace was in blast there, but now I learn there are five blowing, with the prospect of two or three others being put into commission again after the turn of the year. Consumers of hematite iron in the Sheffield area say they can now buy parcels of East Coast at less than 120s. delivered, in spite of the still heavy charges for railway rates, which are considerably above 100 per cent. over those which prevailed in the early summer of 1914. Derbyshire foundry iron is mentioned as low as 97s. 6d. at works, while the price of soft basic billets is little better than £7 15s. The quotations of wire rods and of all descriptions of finished steel productions are declining.

Vickers' Report.

A considerable amount of interest was felt in the issue, a few days ago, of the report of the directors of Vickers Limited for the year 1920. In normal times this document would be expected in the early spring, but discussions with Government departments concerning the prices of various contracts executed during the war have contributed to the delay. The net profits for the twelve months, at £541,261, are little better than one-half the average profits for the preceding four years, and after paying dividends on the preference shares and passing the dividend on the ordinaries, the directors carry forward £991,639, including £846,364 brought down. In their report the directors say that all the company's works in 1920 were very seriously affected by labour disturbances inside and outside and particularly by the prolonged moulders' strike, which threw all engineering and shipbuilding production out of balance. The company's electrical interests were fortunately less affected than the other branches. High prices of coal and of raw material, heavy taxation and the disordered condition of foreign exchanges accentuated the unfavourable circumstances referred to, and the company, in common with others, suffered much from these adverse influences. Customers, under such conditions, and in the hope of a future fall in prices, would naturally only effect purchases when forced by the necessity of their own requirements to do so, and trade was thus reduced to very narrow limits. Moreover, the large proportion of the company's works kept at the disposal of the Government for the production of armaments were practically empty of work, a fact which necessarily added to the difficulties which the company had to face. The fall in the value of all stocks and materials towards the end of the year caused losses which have been provided for in the accounts.

Firth's Directorate Changes.

With the new year will come some interesting changes in the directorate of Thomas Firth and Sons. After about forty years' service with the company, for twenty-eight years of which he has been a director, Mr. J. Rossiter Hoyle, joint managing director with Mr. F. C. Fairholme, relinquishes that position, but will retain a seat on the board and attend at the London office. The managing directorate will devolve wholly on Mr. Fairholme. Mr. Percy Fawcett is retiring from the position of chief engineer, on account of his health, but will remain with the company as consulting engineer with a seat on the board. He is succeeded as chief engineer by his assistant, Mr. H. S. Burn, and Mr. Arthur D. Matthews, for some time past connected with Armstrong's Manchester works, becomes works manager at the Norfolk Works, both Mr. Burn and Mr. Matthews also becoming local directors of Firth's.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Trade Position.

Although the general trade position in the North of England is still very discouraging and unemployment very acute, there is a growing feeling that the corner of the depression has been turned and that a gradual improvement will be experienced after the Christmas holidays. The coal trade has taken on quite a new lease of life. For near future delivery it is difficult to place orders, as most of the collieries are reported to be fully booked. The position in the iron and steel trades is very uncertain. Business is not coming forward in the volume that was expected following the recent drastic reduction in prices, and further concessions will have to be made ere the demand opens out. It is, however, doubtful if manufacturers can afford to make any heavier sacrifice in order to get business, for they are now selling at a heavy loss, and it would appear that only substantial relief in railway rates and fuel costs would enable any further reductions to be made. These will certainly have to come before the trade will revive, and the sooner costs and prices are cut again the sooner will come the long-looked-for revival.

Cleveland Iron Trade.

Little or no material change can be reported in the position of the Cleveland iron trade. Business continues to drag along on very quiet lines and was further restricted this week by the uncertainty regarding the expected reduction in railway rates. A substantial concession might have enabled a further cut to be made in pig iron prices, but the long delay on the part of the railway companies in coming to a decision has created considerable anxiety, and undoubtedly acted as a further check upon business. There is, however, a more optimistic feeling abroad regarding the outlook, and there is a general opinion that business will come forward in better volume after the holidays. There is already a little inquiry for pig iron for delivery in the first few months of next year, and a further cut in prices, would do much to stimulate business. Meanwhile the official quotations remain unchanged, and as there is to be no market next week the prices quoted are likely to rule to the end of the year.

Hematite Pig Iron.

Increased output in the East Coast hematite pig iron trade has brought about keen competition for the orders that are circulating and an easier tendency in prices. Mixed numbers are now being offered at 100s. per ton, with No. 1 at 102s. 6d. Large deliveries are still being made to South Wales, and at the lower figures it is hoped to do a bigger business after the holidays.

Iron-making Materials.

Business is practically at a standstill in the foreign ore trade. For the most part consumers are carrying heavy stocks and still have to take deliveries under contracts. Some sellers are asking 27s. per ton c.i.f. for best Rubio ore, notwithstanding the fall in freight to 7s. 6d., but business could be done at less than that figure. Coke prices are easier, and good medium furnace kinds are now offered at 28s. delivered at the works.

Manufactured Iron and Steel.

Production of manufactured iron and steel has shrunk to very small proportions, and an indication of an early improvement is difficult to discover. New business passing is quite trifling, though to keep their plant partially employed some firms are quite willing to accept orders below cost. With practically no orders on the books most of the works are closing down for a fortnight this week-end, and some indefinitely. Manufacturers of heavy steel rails and fish-plates have reduced quotations £1 per ton, and further cuts in other branches of the steel trade are not improbable. Heavy steel rails are now £9 10s. and fish-plates £14 10s.

The Coal Trade.

The northern coal market is generally very firm throughout, for any date of loading, and merchants find difficulty in covering their requirements for the remainder of the month. Their only hope of purchasing is when a turn opens out unexpectedly; otherwise, the pits are fully stemmed up to the end of the year. The forward market is now giving signs of improvement for the early part of next year, and there is some disposition on the part of buyers to treat for January, and in some cases February, and though the aggregate is small a start has been made. Best steams have been done once or twice for January shipment at 23s., while one of the D.C.R. group is indicating as high as 24s. for next month. Whether this level will be maintained remains to be seen, but if only a stable range of values could be established there is plenty of business possible, and the coal trade would probably enter upon a spell of prosperity. There are already several contracts under discussion, including that for the Norwegian State Railways, for 35,000 tons of best steams, tenders for which have been sent in, and are said to be based on 22s. 6d. to 25s. by the collieries, but some merchants are understood to have undercut these figures. The Copenhagen Gasworks contract, together with a small inquiry for steams, is also on the point of being placed. The Durham forward position, though not quite so firm as that of the more northern coalfields, is still improving in outlook, and probably for a month or more ahead the situation will not deteriorate to any appreciable extent. Among the factors which may have contributed to the temporary improvement may be mentioned the dispute among the French miners, which tends to dislocate the whole coal trade of France, and which is introducing business here. The coke market is slow, with a very poor demand for any class of foundry or furnace. Gas coke is scarcely as well assured as it was and prices are moving downwards.

Work for Shipbuilders.

Four large steamers now being built on the Tyne and Wear have been purchased by Walter Runciman and Co., Limited, for delivery in 1922. The four steamers are about 10,000 tons each; two of them are being built on the Tyne at the yard of the Northumberland Shipbuilding Company, and two in the Wear yard of Doxford and Sons, Pallion. The latter firm was building the vessels for Norwegian owners, but received instructions to cease work on them. Since that time work has been at a standstill, but now that Messrs. Runciman have taken over the contract the yard will proceed as soon as possible with the work.

SCOTLAND.

(From our own Correspondent.)

First Launch from New Shipyard.

DURING the past week the Blythswood Shipbuilding Company, Scotstoun, launched its first ship. The vessel, named the Jackson, is an oil tank steamer of over 10,500 tons deadweight, and several novel features are embodied in the design. The vessel is 455ft. in length, 56ft. in breadth and 34ft. moulded depth, and is of the two-deck type, with long poop bridge and forecastle, and upper flying bridge. The engines and boilers are aft, and the oil compartments amidships, with transverse cofferdams at their boundaries. The holds are divided into eighteen separate oil-tight compartments, with Sumner tanks all fore and aft between the main and upper decks. In a large pump room amidships are installed two large Worthington-Simpson duplex oil pumps, 24in. by 14in. by 20in. stroke, each capable of discharging 300 tons of heavy oil per hour. Two main lines of 12in. wrought iron piping are led therefrom, all fore and aft. The pumps can deliver on both sides of the vessel by either stem discharge pipes or through transverse deck lines. Appliances are also fitted for discharging into lighters or barges alongside. Constructed for American ownership, she is one of several vessels of similar design which the Blythswood Company has on hand. The system of construction has been designed and developed in detail for oil tankers by Dr. James Montgomerie (Lloyd's principal Surveyor in Scotland) and Mr. Macmillan (of the Blythswood Company). The system has been developed with a view to simplicity of construction and to ensure the accessibility and complete drainage of all spaces.

World Competition.

That British shipbuilders would experience keen outside competition has been recognised for some time back, and the time has apparently arrived when that competition is a very definite proposition. At an important launch the other day it was pointed out that Australian builders can construct vessels at a cost £2000 per ship less than the British price, and still pay higher wages than are paid in Britain. As matters stand at present, there are practically no new orders for the Clyde, and empty berths increase with the launches. Rumours of fresh inquiries are abroad, and it is said that tenders for upwards of twelve steamers are being prepared, and these may perhaps bear fruit.

Pig Iron.

Business in Scotch pig iron is extremely small, very little being done either for home or export. In fact, within the past few days a number of furnaces have either been blown out or damped down, and only about half a dozen are now in operation. Even at current prices, the small output could not be disposed of, and makers had no option to closing down under present conditions. Prices have fallen steadily for some time now, and adding to stocks would of necessity entail considerable loss.

Steel and Iron.

The output of steel has been a little better for a week or two, but orders are still very scarce, and the improvement may not be maintained. As prices fall, makers appear to be more hopeful, but the keen competition experienced is making business extremely difficult. The majority of the works are only mildly active, and have great difficulty in keeping even a minimum proportion of their machinery in motion. Plates are very quiet, and while sheets have a fair inquiry, orders are far from being plentiful. Bar iron makers have reaped little benefit from reductions in prices, and rivet, bolt and nut makers are suffering from the stagnation in the shipbuilding and allied industries.

Coal.

The Scotch coal trade has been more active during the past week, owing to an increase in the export department. Shipments to Ireland are on the increase and the Lothians and Fifeshire are busy with orders for continental and Scandinavian destinations. West of Scotland washed nuts are busier, and make up in a measure for a quieter demand for round coal. Prices of the latter are a trifle softer. Coal for home consumption is in poor demand, especially for industrial purposes. Dross is in the nature of a glut at present. House coal, however, is comparatively busy. Aggregate shipments for the past week amounted to 258,486 tons, against 208,615 in the preceding week, and 341,417 tons in the same week in 1913.

Coal Export.

The export demand for Scotch coal has evidently taken a new lease of life; at any rate, it is said that the rush of orders from abroad is quite unusual for the time of the year. Many vessels are now in port awaiting cargoes for Baltic, French and Italian destinations. Inquiries, too, indicate plenty of similar business, with prices at present rates or lower. There is just the danger that a counter revival in home demands might strain resources and force prices up again. At present, however, export is decidedly healthier.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Outlook.

SIGNS that the Christmas holidays are approaching are seen in the fact that there is no keenness to fix up new business for shipment during the remainder of the year. Coals of practically all descriptions are very fully booked up, and it is only natural that firms should not desire to be saddled with getting more cargoes away than can be done without an excessive amount of trouble. Difficulties were already being encountered in the early part of this week in getting supplies of coal together, and with the delays that are occurring it will not be surprising if quite a number of vessels are detained over the holidays. There is a good inquiry for coals for shipment during the first few months of next year, but it remains to be seen whether they will mature, as the indications given as to prices do not inspire confidence that business will result. It is evidently the impression of many buyers abroad that values of South Wales coals are going to fall still further, but if this is to be the case, then the output must be increased to an appreciable extent without incurring extra costs, as otherwise collieries will not be able to work at the prices which are seriously being put forward to tempt sellers. It was fully expected by this time that something definite would have been heard regarding the placing of orders for coals for India. Tenders have gone in for the 250,000 tons of large steams or patent fuel for shipment over the whole of 1922, this business being on a f.o.b. basis; but, in addition to this inquiry, it is reported that collieries have been asked for offers for 300,000 tons of large steams for delivery over next year, for which c.i.f. prices Indian ports are to be furnished. The particular coals to be supplied are Admiralty and leading Monmouthshire qualities. This inquiry has nothing to do with the Indian Government, but has been received from other sources. It will be interesting to know what happens in regard to these Indian inquiries, as they have been so much talked about and everyone is becoming anxious to see to what extent they represent a genuine demand and are not simply "feelers." The Norwegian State Railways are in the market for 35,000 tons of North County coals, but this time Welsh qualities are entirely eliminated. Probably the buyers feel that there is very little to be gained by asking for prices for best Welsh steams, as the quotations for the latter are certain to be on such a level that they reckon that they are likely to get better value for their money by taking North Country descriptions.

Dock Facilities.

There are still numerous complaints about delays to tonnage at the docks in this district. It will be recalled that the Cardiff Chamber of Commerce at its recent meeting urged that the terms of the inquiry by the committee appointed to deal with the whole question of shipping facilities should be extended to cover all questions which in any way related to the prices of coal, *i.e.*, dock charges, &c., the regular working of collieries, and the prompt loading of vessels. Since then Mr. Finlay Gibson, the secretary of the committee, which consists of representatives of the coalowners, exporters, shipbrokers, and the dock companies, has seen Mr. Felix Pole, the general manager of the Great Western Railway, who has stated that as the result of a meeting of the representatives of the South Wales railway and dock companies it had been arranged that the terms of reference should be extended. It is now provided that all matters which the representatives of the trade are of opinion require consideration shall be dealt with by the Bristol Channel Dockowners' Association. A meeting between that Association and the Chambers of Commerce and Coalowners' Committee is to be held to-day (Friday).

Shipping Failures.

During recent months several shipping failures have been recorded, and among the latest is that of the Enterprise Shipping Company, Limited, which had a subscribed capital of £15,000 and owned a small coaster of 625 tons deadweight, the managers being Messrs. W. Woodford and Co. In connection with the collapse of some of the shipping undertakings an interesting report is current that a scheme is under negotiation for the purchase of the steamers of these war-time concerns and for their transfer to a new company with capitalisation on the basis of current shipping values. It is understood that the four steamers of the Stella and the Midland Counties Shipping Companies, which were taken over by the bank, as the mortgagee, are likely to form the nucleus of the new fleet, which will probably eventually total about fifteen to twenty steamers with a deadweight capacity of approximately 75,000 to 100,000 tons. Hopes are entertained that shareholders who have suffered by the failure of the undertakings whose tonnage it is now proposed to acquire, will be allowed to participate in the scheme, thus giving them a chance to recoup their losses.

Dock Workers' Pool.

Dock pilots, boatmen and riggers are now all back at work and no further trouble is being experienced, but there is an interesting sequel to the recent dispute, inasmuch as the pooling system which was in operation in the case of the coal trimmers has now been adopted by the Cardiff dock pilots and the boatmen. Both work and earnings are to be pooled and the men will be employed by rota of three watches with eighteen dock pilots and thirty boatmen on duty at a time. This arrangement had been come to with the sanction of the Cardiff Railway, from whom they will receive their instructions in regard to the distribution of work. Some of the shipowners object to the rota system, as they prefer to employ their own regular hands. Under the recent new tariff agreement there is no obligation on the part of owners or captains to employ dock pilots or boatmen.

Question of Nationalisation.

The new president of the South Wales Miners' Federation, Mr. Vernon Hartshorn, has by no means given the impression that it is his intention to keep the industry free from strife, as he has reopened the question of private enterprise *versus* nationalisation. This has brought Mr. Finlay Gibson, the secretary of the Coalowners' Association, into the field with facts regarding the service which private enterprise has rendered. He points out that in ten years before Government control the cost of working increased by only 3s. per ton and the selling price by the same amount. Under five years of control, however, the cost increased by nearly 43s. per ton. In the inland market the selling price was ruled by Government regulations, but even under the orders issued by the Board of Trade the selling price in the inland market was increased by 23s. 2d. per ton, bringing the pithead price to approximately 37s. 6d. per ton, compared with 12s. 1d. in 1913. He adds that it is less than six months since de-control became effective and the industry restored to the direction of private enterprise, and yet the cost of 42s. per ton has been reduced to about 20s. per ton and the selling price has been reduced even to more than a corresponding extent.

Dry Dock Workers' Wages.

Mention was made recently of the demand by the Dry Dock Owners' Federation for a reduction in the wages of its workmen. Since then there has been a conference between representatives of the employers and the various trades affected. As the result of a long discussion the employers' representatives agreed to meet the wishes of the joint trades to extend the notices of reduction which were issued on November 30th last and to amend the terms as follows:—5s. per week in the pay week commencing February 2nd; 5s. per week in the pay week commencing March 2nd; and 2s. 6d. per week in the pay week commencing April 6th, on the clear understanding that the complete case for the reduction of 12s. 6d. as set out is to be submitted by the representatives of the men to their members. The conference further decided that the final consideration of the matter should be deferred for a month. The wages of the men are approximately £3 12s. per week.

Current Business.

There is not a great deal of life in the market, but this is not unexpected, in view of the nearness of the holidays, and there is not much prospect that great activity will be in evidence until at least the first week in the new year, by which time the holiday feeling will have been got over and colliery salesmen will be in a better position to say what coals they will have to dispose of. For the time being collieries are very well booked up until the early part of next month, and in some cases until the middle of January, so that their position is a comparatively comfortable one. The tone of the market is very steady on the basis of about 26s. for best Admiralty large and 25s. 6d. for second qualities. Monmouthshire large descriptions range from 22s. 6d. to 24s. 6d., and best steam smalls command 18s. 6d. to 19s. There is no change of note in patent fuel and coke, though one or two leading makes of the former are well booked for the next few weeks.

THE ROYAL INSTITUTION.

THE following programme of lectures to be delivered during the Before-Easter Session of the Royal Institution of Great Britain has been arranged:—Friday Evening Discourses, at 9 p.m.: January 20th, Sir James Dewar, F.R.S., Fullerian Professor of Chemistry, "Soap Films and Molecular Forces"; January 27th, Viscount Burnham, "Journalism"; February 3rd, Lieut.-Colonel Sir Francis Younghusband, "The Mount Everest Expedition"; February 10th, Dr. W. D. Halliburton, F.R.S., Professor of Physiology, King's College, London, "The Teeth of the Nation"; February 17th, Dr. S. M. Watson, Jodrell Professor of Zoology and Comparative Anatomy, University of London, "History of the Mammalian Ear"; February 24th, Dr. John Joly, F.R.S., Professor of Geology, University of Dublin, "The Age of the Earth"; March 3rd, Mr. C. Morley Wenyon (subject not yet announced); March 10th, Dr. Thomas R. Merton, F.R.S., Professor of Spectroscopy, University of Oxford, "Problems in the Variability of Spectra"; March 17th, Dr. A. P. Laurie, Principal, Heriot-Watt College, Professor of Chemistry to Royal Academy, "The Pigments and Mediums of the Old Masters"; March 24th, Dr. F. G. Donnan, F.R.S., Professor of Chemistry, University of London, "Auxiliary International Languages"; March 31st, Mr. Arthur B. Walkley, author of "Drama and Life," &c., "Jane Austen"; and April 7th, Sir Ernest Rutherford, F.R.S., Professor of Natural Philosophy, R.I., "Evolution of the Elements." *Children's Lectures:* As already announced, the children's Christmas lectures, which will be delivered by Dr. J. A. Fleming, F.R.S., on the afternoons of (1) Thursday, December 29th, (2) Saturday, December 31st, (3) Tuesday, January 3rd, (4) Thursday, January 5th, (5) Saturday, January 7th, and (6) Tuesday, January 10th, at three o'clock, have for their subject "Electric Waves and Wireless Telephony." The subjects of the lectures are:—"Surface Waves on Liquids;" "Waves in Air;" "The Telephone;" "Electric Oscillations;" "Electric Waves;" and "Wireless Telephony." *Courses of Lectures:* "Physiology as applied to Agriculture," by Dr. F. H. A. Marshall, F.R.S., Reader in Agricultural Physiology, University, Cambridge, two lectures on Tuesdays, January 17th, 24th; "Variable Stars," (1) Short Period Variables, (2) Long Period Variables, (3) Our Sun, by Dr. H. H. Turner, F.R.S., Savilian Professor of Astronomy, University, Oxford, three lectures on Tuesdays, January 31st, February 7th, 14th; "Anthropological Problems of the British Empire," Series I., Radial Problems in Asia and Australasia, by Sir Arthur Keith, F.R.S., Fullerian Professor of Physiology, R.I., five lectures on Tuesdays, February 21st, 28th, March 7th, 14th, 21st; "Earth Movements," by Dr. John W. Evans, F.R.S., Lecturer on Petrology, Imperial College of Science and Technology, two lectures on Tuesdays, March 28th, April 4th; "Mountain Birds of Scotland, Sea Birds and Seals," by Mr. Seton Gordon, two lectures on Thursdays, January 19th, 26th; "Droughts and Floods," by Sir Napier Shaw, F.R.S., Professor of Meteorology, Royal College of Science, two lectures on Thursdays, February 2nd, 9th; "Dyeing: Ancient and Modern," by Mr. Arthur G. Perkin, F.R.S., Professor of Colour Chemistry and Dyeing, University, Leeds, two lectures on Thursdays, February 16th, 23rd; "The Menace of the Insect Pest: The Balance of Life in relation to Insect Pest Control," by Mr. H. Maxwell Lefroy, Professor of Entomology, Imperial College of Science and Technology, two lectures on Thursdays, March 2nd, 9th; "The Cinema as a Zoological Method," by Dr. P. Chalmers Mitchell, F.R.S., Secretary, Zoological Society of London, two lectures on Thursdays, March 16th, 23rd; "Landscape Etchers: New and Old," by Mr. Arthur M. Hind, Slade Professor of Fine Arts in the University of Oxford, two lectures on Thursdays, March 30th, April 6th; "The Evolution of Organ Music," by Dr. Charles Macpherson, President, Royal Colledge of Organists (with musical illustrations), two lectures on Saturdays, January 21st, 28th; "Humorists of the Seventeenth Century," (1) Sir Thomas Browne, (2) Thomas Fuller, by Dr. Ernest de Selincourt, Professor of English Literature, University, Birmingham, two lectures on Saturdays, February 4th, 11th; "Masterpieces of Greek Sculpture," by Dr. Ernest A. Gardner, Litt.D., Yates Professor of Archæology, University College, London, two lectures on Saturdays, February 18th, 25th; "Radioactivity," by Sir Ernest Rutherford, F.R.S., Professor of Natural Philosophy, R.I., six lectures on Saturdays, March 4th, 11th, 18th, 25th, April 1st, 8th.

Current Prices for Metals and Fuels.

IRON ORE.

N W. Coast—	
Native	37/-
(1) Spanish	28/-
(1) N. African	28/-
N.E. Coast—	
Native	—
Foreign (c.i	27/-

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	6 0 0	—
No. 1 Foundry	6 0 0	—
No. 3 ,,	5 15 0	—
N.E. Coast—		
Hematite Mixed Nos.	5 0 0	5 0 0
No. 1	5 2 6	5 2 6
Cleveland—		
No. 1	5 5 0	5 10 0
Silicious Iron	—	—
No. 3 G.M.B.	5 0 0	5 5 0
No. 4 Foundry	4 15 0	4 15 0
No. 4 Forge	4 10 0	4 10 0
Mottled	4 5 0	4 5 0
White	4 5 0	4 5 0
Midlands.		
Staffs.—		
All-mine (Cold Blast)	15 0 0	—
Part Mine Forge	*None offering.*	
North Staffs. Foundry	5 10 0	—
(3) Northampton—		
Foundry Nos. 2 and 1	*Nominal.*	
,, No. 3	4 15 0	—
,, Forge	4 4 0	—
(3) Derbyshire—		
No. 3 Foundry	4 12 6 to 4 15 0	
Forge	4 5 0 to 4 7 6	—
Lincolnshire—		
Basic	*Uncertain.*	
Foundry	,,	—
Forge	,,	—
(4) N.W. Coast—		
N. Lancs. and Cum.		
Hematite Mixed Nos.	6 5 0	—

MANUFACTURED IRON

	Home. £ s. d.	Export £ s. d.
Scotland—		
Crown Bars	12 10 0	—
Best ,,	17 0 0	—
N.E. Coast—		
Common Bars	12 10 0	—
Marked ,,	18 0 0	—
Tees	14 10 0	—
Lancs.—		
Crown Bars	13 0 0	—
Hoops	16 5 0	16 0 0
S. Yorks.—		
Crown Bars	13 0 0	—
Best ,,	14 0 0	—
Hoops	15 5 0	—
Midlands—		
Marked Bars (Staffs.)	16 0 0	—
Crown Bars	12 10 0 to 13 0 0	
Nut and Bolt Bars	12 5 0 to 12 10 0	
Gas Tube Strip	13 10 0	—
Hoops (*Nom.*)	16 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	14 0 0	—
Ship Plates ⅜in. and up	10 10 0	—
Sections	10 0 0	—
Steel Sheets ⅛in. to ⅜in.	12 5 0	—
Sheets (Gal. Cor. 24 B.G.)	—	17 0 0

STEEL (*continued*)

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	10 10 0	—
Angles	10 0 0	—
Boiler Plates	16 0 0	—
Joists	10 10 0	—
Heavy Rails	9 10 0	—
Fish-plates	14 10 0	—
Channels	14 10 0	—
Hard Billets	9 10 0	—
Soft Billets	7 10 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	11 0 0	—
Light ,,	13 0 0 to 15 0 0	
Billets	9 10 0	—
Ship Plates	10 10 0	—
Boiler ,,	16 0 0	—
Manchester (*Prices irregular and uncertain, unchanged*)—		
Bars (Round)	10 0 0 to 12 0 0	
,, (others)	11 0 0 to 12 0 0	
Hoops (Best)	15 5 0	15 0 0
,, (Soft Steel)	12 5 0	12 0 0
Plates	£10 to 12	10 0 0
,, (Lancs. Boiler)	16 0 0	—
Sheffield—		
Siemens Acid Billets	13 0 0	—
Bessemer Billets	12 10 0	—
Hard Basic	10 0 0	—
Soft ,,	8 10 0 to 10 0 0	
Hoops	13 5 0	—
Soft Wire Rods	10 0 0	—
Midlands—		
Small Rolled Bars	10 0 0 to 10 10 0	
Bessemer Billets	7 10 0 to 8 0 0	
(2) Hoops	12 0 0 to 12 10 0	
Gas Tube Strip	10 15 0 to 11 0 0	
Sheets (24 W.G.)	15 0 0	—
Galv. Sheets (f.o.b. L'pool)	17 10 0 to 18 0 0	
Angles	10 0 0	—
Joists	10 10 0	—
Tees	11 0 0	—
Bridge and Tank Plates	10 10 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	20/- to 21/-
Block Tin (cash)	171 10 0
,, (three months)	173 5 0
Copper (cash)	66 12 6
,, (three months)	67 12 6
Spanish Lead (cash)	25 10 0
,, (three months)	24 12 6
Spelter (cash)	27 10 0
,, (three months)	27 12 6
Manchester—	
Copper, Best Selected Ingots	69 0 0
,, Electrolytic	75 0 0
,, Strong Sheets	98 0 0
,, Loco Tubes	0 1 2½
Brass Loco Tubes	0 1 0½
,, Condenser	0 1 4½
Lead, English	27 0 0
,, Foreign	25 10 0

(*Metal prices practically unchanged*).

FERRO ALLOYS,

(*All prices now nominal*).

	Per Ton.	Per Unit
Tungsten Metal Powder	1/8 per lb.	
Ferro Tungsten	1/6 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£28	12/-
,, 6 p.c. to 8 p.c. ,,	£26	10/-
,, 8 p.c. to 10 p.c. ,,	£26	10/-
,, Specially Refined		
Max. 2 p.c. carbon	£79	28/-
,, 1 p.c. ,,	£94	32/-
,, 0·75 p.c. carbon	£110	41/-
,, carbon free	2/8 per lb.	
Metallic Chromium	5/6 per lb.	
Ferro Manganese	(per ton) £18 for home.	
,, Silicon, 45 p.c. to 50 p.c.	£12 10 0 scale 5/- per unit	
,, ,, 75 p.c.	£20 0 0 scale 6/- per unit	
,, Vanadium	21/- per lb.	
,, Molybdenum	9/- per lb.	
,, Titanium (carbon free)	1/6 per lb.	
Nickel (per ton)	£190	
Cobalt	14/6 per lb.	
Aluminium (per ton)	£110 to £120 (British Official).	

FUELS.

	Export.
Scotland.	
Lanarkshire—	
(f.o.b. Glasgow)—Steam	24/6
,, ,, Ell	25/6
,, ,, Splint	26/- to 30/-
,, ,, Trebles	26/-
,, ,, Doubles	24/-
,, ,, Singles	18/-
Ayrshire—	
(f.o.b. Ports)—Steam	24/-
,, ,, Splint	26/6
,, ,, Trebles	25/6
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	20/6 to 25/-
Screened Navigation	28/-
Trebles	26/-
Doubles	24/-
Singles	18/6
Lothians—	
(f.o.b. Leith)—Best Steam	24/-
Secondary Steam	23/6
Trebles	25/6
Doubles	23/-
Singles	17/6
England.	
(8) N.W. Coast—	
Steams	34/-
Household	40/- to 55/-
Coke	34/- to 36/6
Northumberland—	
Best Steams	24/- to 25/-
Second Steams	21/6 to 22/-
Steam Smalls	15/-
Unscreened	21/6
Household	25/- to 30/-
Durham—	
Best Gas	23/- to 24/-
Second	20/- to 22/-
Household	25/- to 30/-
Foundry Coke	37/6 to 40/-

Sheffield—	Inland.
S. Yorks. Best Steam Hards	25/- to 26/-
Derbyshire Hards	24/- to 25/-
Seconds	23/- to 24/-
Cobbles	23/- to 24/-
Nuts	22/- to 23/-
Washed Smalls	17/- to 18/-
Best Hard Slacks	17/6 to 18/6
Seconds ,,	17/- to 17/6
Soft Nutty ,,	17/- to 17/6
Pea ,,	11/6 to 12/6
Small ,,	9/- to 10/-
House, Branch	29/- to 41/-
,, Best Silkstone	37/6 to 39/-
Blast Furnace Coke (Inland and Export)	22/6 to 27/6

Cardiff—	(9) South Wales.
Steam Coals:	
Best Smokeless Large	25/6 to 26/-
Second ,, ,,	25/- to 25/6
Best Dry Large	25/6 to 26/-
Ordinary Dry Large	24/6 to 25/-
Best Black Vein Large	23/6 to 24/6
Western Valley ,,	23/- to 23/6
Best Eastern Valley Large	23/- to 23/6
Ordinary ,, ,,	21/6 to 22/6
Best Steam Smalls	18/- to 19/-
Ordinary ,,	12/6 to 17/6
Washed Nuts	35/- to 40/-
No. 3 Rhondda Large	29/- to 30/-
,, ,, Smalls	20/- to 21/-
No. 2 ,, Large	24/- to 25/-
,, ,, Through	20/- to 22/-
,, ,, Smalls	15/- to 17/-
Coke (export)	35/- to 40/-
Patent Fuel	26/- to 28/6
Pitwood (ex ship)	37/6 to 40/-
Swansea—	
Anthracite Coals:	
Best Large	57/6 to 60/-
Seconds	52/6 to 55/-
Red Vein	47/6 to 50/-
Big Vein	55/- to 57/6
Machine-made Cobbles	72/6 to 75/-
Nuts	72/6 to 75/-
Beans	58/6 to 60/-
Peas	20/- to 22/-
Breaker Duff	7/9 to 8/3
Rubbly Culm	11/6 to 12/-
Steam Coals:	
Large	24/- to 25/-
Seconds	23/- to 24/-
Smalls	12/6 to 16/-
Cargo Through	20/- to 22/-

(1) Delivered. (2) Net Makers' works. (3) At furnaces. (4) Delivered Sheffield (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—F.O.B. Glasgow.

(8) Except where otherwise indicated coals are per ton at pit for inland and f.o.b. for export and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b.

French Engineering Notes.

(From our Correspondent in Paris.)

The State Railways.

THE State management of commercial and industrial undertakings has given such disastrous results that the country will no longer tolerate new State monopolies, and is endeavouring, indeed, to wrest from the army of functionaries some of the oldest and most cherished monopolies which are of far less benefit to the national finances than they would be if left to private or public companies. Despite the opposition of Socialists, some of the monopolies will have to go, and there is a prospect of the State railways undergoing such a transformation as will bring them more into harmony with the business character of railway enterprise. During the last debate in Parliament upon the railway estimates it was urged that something should be done to infuse a little more business spirit into the management of the State railways, and three commissions were appointed to go fully into the matter. Their reports have now been issued, from which it appears that one is in favour of an exchange of lines between the State and the Orleans Company, so as to give more homogeneity to each system; another proposes to replace the present managing Council of the State system by a board of directors which would include men of commercial and industrial training; and the third suggests the handing over of the State railways to a national company which would provide the capital necessary for bringing the railway equipment up to date, the State having nothing more to do with the railways except to profit from the financial advantages usually derived from such concessions. It is not expected that any one of these recommendations will be adopted in its entirety, and it is supposed that they will all be merged more or less into a final scheme under which a strong commercial character will be imparted to the management, and probably there may be an appeal to the public for funds. In that case the State would certainly have to hand over the executive management to an independent board of directors. There is so much to be done on the State railway system in order to bring it to a fairly high degree of efficiency that, in the present condition of the public treasury, there is a possibility of the money being doled out and the work delayed for many years, whereas a public loan might permit of the programme being carried out much more rapidly. The reports are to be discussed at an early meeting of the Commissions, when a final decision will be come to and submitted for the approval of the Minister of Public Works.

Tidal Power.

The number of methods of practically utilising tidal power is very small, according to M. Bare, who recently presented an interesting communication on the subject to the Association des Anciens Elèves de l'Ecole des Travaux Publics. After showing that the results obtained by using the movement of the tides or the velocity of the waves would be too poor to be of any value, M. Bare declared that the only practical scheme was to utilise a head of water produced by constructing a barrage across a narrow bay, and even in that case the variations of head from zero to maximum would render the scheme impossible unless something were done to regulate the supply and provide for the interruptions at high and low tides. Consequently, the tidal installation must be supplemented by another where a constant fresh water head is obtainable, and the turbines of the tidal plant must run both ways and maintain a good efficiency at different speeds. In the experimental installation, which is to be laid down at Aber-Vrac'h, near Brest, the barrage will consist of three concrete caissons, the central one containing four turbines of an entirely new pattern and provided with valves to permit of their running in one direction or another, according to whether the tide is rising or falling. The turbines will be in pairs, each pair driving one alternator, the speed of which will be regulated according to the varying speeds of the turbines by a special device. Each turbine will develop 1300 horse-power under the maximum head. The tidal installation will be connected up with another hydro-electric plant nearly 6 kiloms. away, where a barrage will be constructed across the valley of the river Diouris, to hold up about 12 million cubic metres of water. The maximum head will be 39 m. The generating plant will consist of four turbines, each of 1350 horse-power, and two alternators of 2700 horse-power, as well as two pumps, which may be employed occasionally to replenish supplies behind the barrage, when they will absorb a maximum of 3200 horse-power. It is expected that the tidal installation will produce 8,000,000 kilowatts a year, and the Diouris fresh-water plant 3,000,000 kilowatts. The cost at which the current will be supplied is estimated to be appreciably above what is possible with the hydro-electric plants in the mountainous regions, but it is expected to show a satisfactory economy over coal. In a word, tidal power installations can only be worked in conjunction with other sources of electrical energy which will ensure regularity of supply, and the initial cost is necessarily very high. For that reason there is some opposition to the putting of this experimental scheme in hand at a time when the country's finances are so unsatisfactory, but as the question of realising fuel economies is of the first importance it is believed that the Minister of Public Works will be able soon to obtain the credits for carrying out the scheme.

Continuous Brakes.

Among the modifications to rolling stock imposed by the Minister of Public Works is the application of the continuous brake to goods trains, of which the vehicles are at present braked by hand. The accident at Houilles several months ago was due to inefficient brakes, and several other catastrophes have been attributed to the running back of wagons after the rupture of couplings. The tests of continuous braking systems were continued last week on a line with particularly heavy gradients in the neighbourhood of Clermont-Ferrand. The tests were made on a train with sixty vehicles weighing 1600 tons. The systems tried were the Westinghouse, Clayton-Hardy and Lipkowski. The conditions of the test were particularly severe, and the results extremely variable, and it will not be known until the official report is published whether one or other of the systems was entirely satisfactory.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

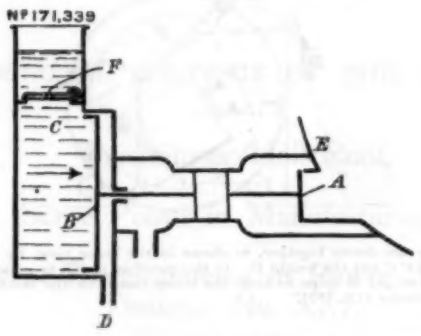
Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C. at 1s. each.

The date first given is the date of application; the second date at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM ENGINES.

171,339. April 25th, 1921.—UNIFLOW ENGINES, J. Romeyn, 162, Rue Emile Feron St. Gilles, Brussels.

THE valve A is intended to relieve the compression pressure in uniflow engine cylinders when they are being run temporarily with a bad vacuum. On the stem of the valve there is a piston B, which is subject to atmospheric pressure on the left, through the intervention of the liquid in the chamber C. The opposite

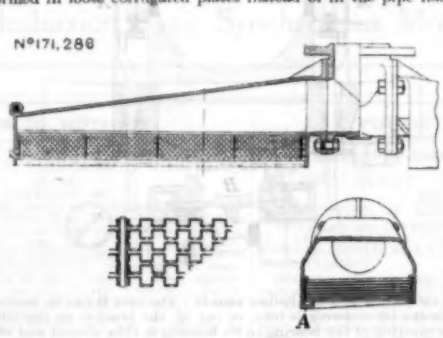


side of the piston B is in communication with the condenser, by way of the branch D. When the pressure in the cylinder E rises abnormally on account of poor vacuum at D, the valve A will open, as the piston B will be nearly in equilibrium, and the liquid in C can escape through the valve F. The reseating of the valve A is delayed by the liquid having to find its way back into C through a small hole in the valve F. With a good vacuum the difference of pressures on the piston B keeps the valve A closed.—*November 17th*, 1921.

STEAM GENERATORS.

171,286. October 11th, 1920.—STEAM SEPARATORS, R. S. Portham and J. Dorman, 22, Billiter-street, London, E.C. 3.

In this steam separator, which is of the type for mounting inside the steam space of the boiler, the usual perforations are formed in loose corrugated plates instead of in the pipe itself.

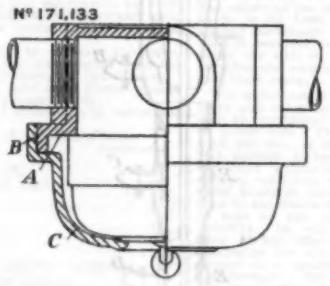


The detail sketch shows how the plates are nested together so that the perforations are baffled by the corrugations above. The plates are slid into the branch pipe endways and are given a slight transverse slope to induce water separated from the steam to trickle down into the channel A, and thence back into the boiler.—*November 17th*, 1921.

SWITCHGEAR.

171,133. July 2nd, 1920.—IMPROVEMENTS IN ELECTRIC CONDUIT BOXES, Max John Railing and Thomas Taylor, both of 67, Queen Victoria-street.

The conduit box described in this specification is provided with a seating A. The box is screwed as shown at B to take the cover C, the shape of this cover being varied to take various kinds of fittings, such as switches, &c., the fittings being clamped

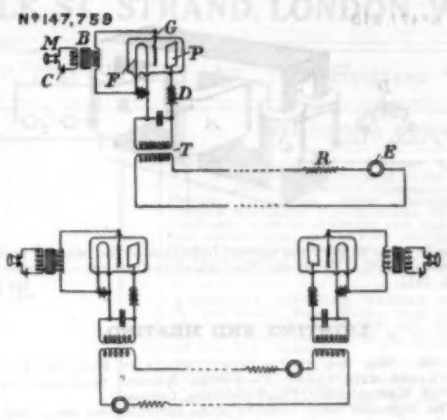


to the seating A by screwing on the cover. In the case illustrated a tumbler switch is shown clamped between the seating A and the cover C. There are six other illustrations showing how other fittings can be dealt with in accordance with the invention.—*November 2nd*, 1921.

TELEGRAPHS AND TELEPHONES.

147,757. July 8th, 1920.—IMPROVEMENTS IN TELEPHONE AND THE LIKE SYSTEMS, Marius Latour, of 79, Boulevard Houssman, Paris.

This invention relates to improvements in telephone systems, and particularly to those suffering from disturbances arising from induction or parasitic currents. In the upper diagram a microphone M is connected to the primary of a transformer B, called the input transformer, through a battery C. The secondary of the input transformer is connected to the grid G and filament F of a thermionic tube amplifier with an anode P. The external portion of the anode filament circuit includes the anode battery D, and the primary winding of another transformer T, called the output transformer. The secondary of the output transformer is connected to the line, and the remote ends of the line

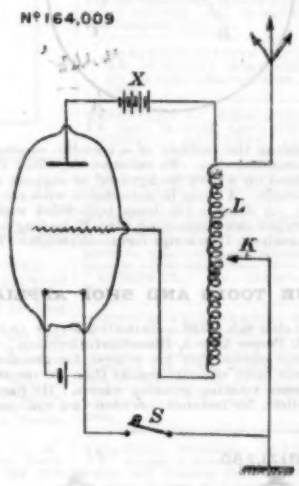


are connected to a receiver E and resistance R. The lower diagram shows the arrangement applied to two terminal stations. If the amplification at either station be made such that the intensity of the speech currents in the line appreciably exceeds the intensity of the induced parasitic currents, it is easily understood that a systematic and proportional attenuation of both, up to a certain value, will result in the practical extinction of the weaker disturbing currents, while the stronger speech currents will subsist.—*November 8th*, 1921.

WIRELESS TELEGRAPHY.

164,009. July 7th, 1920.—IMPROVEMENTS IN ELECTRO-MAGNETIC WAVE-SIGNALLING SYSTEMS, Marius Latour, of 79, Boulevard Houssmann, Paris.

This invention relates to a continuous wave-signalling system, comprising an aerial circuit and a thermionic tube generator, in which the inductances of the anode and grid circuits are combined into a common coil L, the system giving out different

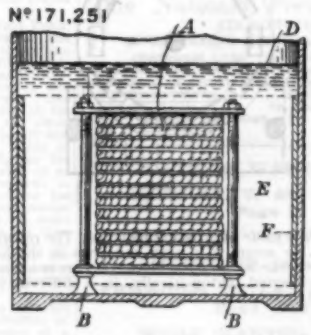


wave lengths according to the position of the sliding contact K. The source of power X may be connected with a resistance in such a way as to avoid high initial voltages in the anode filament circuit on the depression of the signalling key S.—*November 7th*, 1921.

TRANSFORMERS.

171,251. June 15th, 1920.—IMPROVEMENTS IN AND RELATING TO ELECTRIC TRANSFORMERS AND LIKE APPARATUS, The British Thomson-Houston Company, of 83, Cannon-street, E.C. 4.

In the drawing A represents an iron core type of reactor mounted on supports B in a container, having walls made of



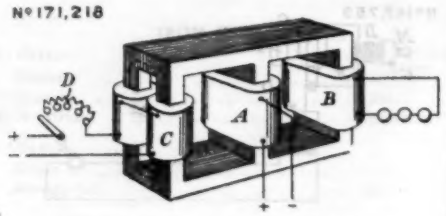
steel and containing oil D for cooling purposes. The stray field from the air core reactor A is confined to the space E. A magnetic shield F, composed of copper, is secured to the interior of the tank, and when the reactor is in service short-circuit currents flow in the plate and prevent the flux emanating

from the coil A passing beyond the shield F. Several modifications of the invention are described.—*November 17th*, 1921.

171,218. August 26th, 1920.—Improvements in and relating to Means for Regulating Alternating Current Circuits, The Igranic Electric Company, of 147, Queen Victoria-street, London, E.C. 4.

The transformer described in this specification has the usual primary and secondary windings A and B and a third winding C, which is excited with direct current through a regulating resist-

No 171,218.



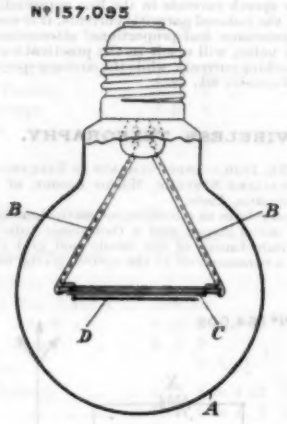
ance D, so as to vary the mutual induction of the primary and secondary coils. There are three other illustrations.—*November 17th*, 1921.

LIGHTING AND HEATING.

157,095. May 3rd, 1918.—Improvements in Electric Gas Lamps with Glow Discharge, Johanna Goosmann, of 24, Kastanienalle, Charlottenburg, Germany.

The improved lamp consists of an incandescent lamp bulb filled with rare gas and in which the lighting effect is produced by the negative glow forming on the cathode. Very simple and effectively illuminated script signs are produced with these

No 157,095.



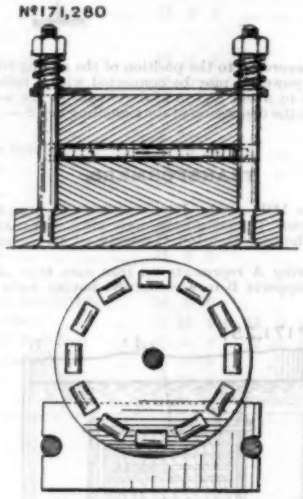
lamps by forming the cathode of a metallic conductor in the form of the required sign. To enhance the effect the cathode may be disposed on a dark background or support of coloured glass, for example. A lamp in accordance with the invention is illustrated. A denotes the lamp bulb filled with rare gas, into which project two conducting wires B, leading to the anode C and to the cathode D in script form.—*November 17th*, 1921.

MACHINE TOOLS AND SHOP APPLIANCES.

171,280. October 6th, 1920.—Grinding Balls and Rollers, P. Bruhl, Berger Ufer 3, Düsseldorf, Germany.

The inventor claims that his process for grinding balls or rollers produces more accurate results than the usual system of grinding between rotating grinding wheels. He passes and repasses the rollers, for instance, between two stationary blocks,

No 171,280.



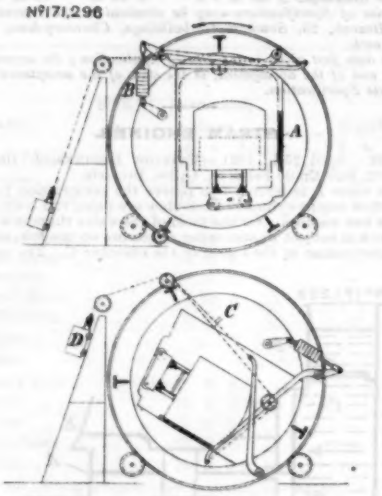
one of which is made of grinding material. The rollers are held, and moved, by means of a cage, as shown in the lower view. After each passage between the blocks they are removed from the cage and reinserted, automatically, in a different position.—*November 17th*, 1921.

CRANES AND CONVEYORS.

171,296. October 27th, 1920.—Truck Tipplers, G. A. P. Provay, P.O. Box 321, Lourenço Marques, Portuguese East Africa.

This invention relates to means for clamping trucks in wagon tipplers. A timber bolster A is provided at the side of the tippler for supporting the truck as it is tipped, while the truck is held in place by the system of overhead levers shown, which bear on the top sides of the truck. In the normal position these levers are kept clear by the weight B, but when the truck is tipped

No 171,296.



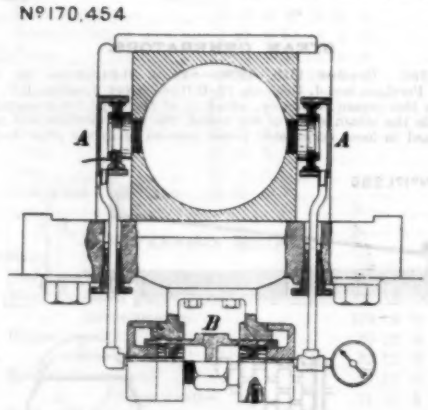
they are drawn together, as shown in the lower view, by the rope C C and the weight D. In this position, it will be noticed, the weight B helps to keep the levers closed on the truck.—*November 17th*, 1921.

MISCELLANEOUS.

170,454. August 24th, 1920.—Printing Press Cylinder Bearings, A. Terrey, 26, Keith-road, Hayes, Middlesex.

For the purpose of controlling the pressure of the impression cylinder upon the printing cylinder the inventor employs hydraulic rams A A on opposite sides of the bearings for the impression cylinder. These rams are connected by pipes with

No 170,454.

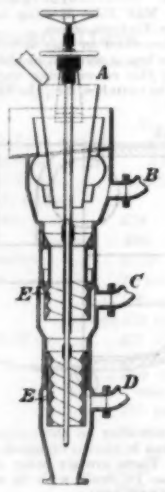


the interior of another hollow ram B. The ram B can be moved endways by screwing it into, or out of, the bracket on the left. The position of the bearing in its housing is thus altered and the pressure between the two cylinders controlled.—*October 27th*, 1921.

171,267. September 24th, 1921.—Hydraulic Separators for Minerals, E. G. Weddell, Merthyrmawr-road, Bridgend, Glamorgan.

In this washer the coal is fed in through the hopper A, while water is supplied at B, C and D. The water swirls up through the grooved sorting columns and carries with it the lighter

No 171,267.



material, or coal, while the heavier shale, &c., fall to the bottom. The sleeves E E, which form the sorting columns, can be moved axially to adjust the washer for different classes of material.—*November 17th*, 1921.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

THURSDAY, DECEMBER 29TH.

Royal Institution of Great Britain.—Albemarle-street, London, W. 1. Children's lectures: "Electric Waves and Wireless Telephony." Lecture I., "Surface Waves on Water and Liquids." 3 p.m.

FRIDAY, DECEMBER 30TH.

Junior Institution of Engineers.—Caxton Hall, S.W. Questions and general discussion. 8 p.m.

Institution of Production Engineers.—Institution of Mechanical Engineers, Storey's gate, S.W. 1. Paper, "The Costing System and its relation to Production," by Mr. G. H. Hales. Lantern. 7.30 p.m.

SATURDAY, DECEMBER 31ST.

Royal Institution of Great Britain.—Albemarle-street, London, W. 1. Children's Lectures: "Electric Waves and Wireless Telephony." Lecture II., "Compressional Waves in Air." 3 p.m.

TUESDAY, JANUARY 3RD, 1922.

Institution of Automobile Engineers.—Chamber of Commerce, New-street, Birmingham. Paper, "Experiments with Weldless Steel Tubing, as used in Construction," by Mr. W. W. Hackett. 7 p.m.

WEDNESDAY, JANUARY 4TH.

Institute of Cost and Works Accountants.—Hall of the Institute of Chartered Patent Agents, Staple Inn Buildings, Holborn. Lecture, "Financial Planning," by Mr. H. G. Jenkins. 7 p.m.

Institution of Electrical Engineers: Wireless Section.—Savoy-place, Victoria Embankment, W.C. 2. "High-speed Wireless Telegraphy," by Lieut.-Colonel A. G. T. Cusius. 6 p.m.

THURSDAY, JANUARY 5TH.

Royal Aeronautical Society.—Royal Society of Arts, John-street, Adelphi, W.C. 2. "Specialised Aircraft," by Wing-Commander W. D. Beatty. 5.30 p.m.

FRIDAY, JANUARY 6TH.

Junior Institution of Engineers.—Caxton Hall, S.W. Lecturette, "Stone and Marble-working Machinery," by Mr. A. E. Bingham. Lantern. 8 p.m.

Institution of Mechanical Engineers.—Storey's-gate, S.W. 1. Joint meeting with the Society of Chemical Industry. "The Co-operation of the Engineer and Chemist in the Control of Plants and Processes," by Mr. G. M. Gill. 6 p.m.

SATURDAY, JANUARY 7TH.

Institution of Locomotive Engineers (Scottish Centre).—Ball Room, Grosvenor Restaurant, Glasgow. Smoking concert. 6.30 p.m.

TUESDAY, JANUARY 10TH.

Junior Institution of Engineers.—Visit to Charlton Works of the United Glass Bottle Manufacturers, Limited, at 2.30 p.m.

WEDNESDAY, JANUARY 11TH.

Institution of Automobile Engineers.—Institution of Mechanical Engineers, Storey's-gate, S.W. 1. "An Investigation of Certain Aspects of the Two-stroke Engine for Automobile Vehicles." 8 p.m.

THURSDAY, JANUARY 12TH.

Royal Aeronautical Society.—Royal Society of Arts, John-street, Adelphi, W.C. 2. Annual Juvenile Lecture. Talk on "Boats that Fly," by Major D. C. H. Hume. 3 p.m.

TUESDAY, JANUARY 31ST.

Institution of Civil Engineers: Manchester and District Association.—Paper on "Tidal Power Development," by Professor A. H. Gibson, D.Sc. 6.30 p.m.

Contracts.—The Westinghouse Electric International Company announces that it has received from its Japanese agent, Takata and Co., from the Daido Denrioku K.K. (the Daido Electric Power Company of Japan), an order for electrical apparatus for two large hydro-electric plants which are to form a part of a super-power system for the Tokio district. The current is to be transmitted at 154,000 volts. The total value of this order is given as being about 2,000,000 dols.

Flexible Shafting.—A small sample of flexible shafting which has been sent to us by Messrs. Fraser and Glass, of Assembly Works, Middle-lane, Hornsey, gives indications of considerable ingenuity in its manufacture. The shaft is intended for comparatively light services, such as driving speedometers, sheep-shearing machines or portable drills, and will work easily inside a flexible tube $\frac{1}{2}$in. in diameter. The shaft itself is built up of little steel U-shaped links about $\frac{1}{2}$in. long, which are connected together by a rivet joining the limbs of each U and passing through the bend of the next. A strong chain is thus formed which has very little back-lash in rotary movement, and in which every two links provide a universal action. It is obvious that this shaft is more convenient for connecting up at the ends than is the case with the flexible wire type, which has to be soldered, while it does not rub on the casing to the same extent. It is so flexible that it can be run in a casing with a radius of curvature of $1^{15}/_{16}$in. without getting hot.

Municipal Electrical "Old Stagers."—The suggestion that a reunion of those engaged in municipal electrical work in its early days should be held met with so remarkably cordial a response that a small committee was formed to make arrangements to carry it into effect. The members of this Committee are:—Messrs. S. W. Baynes, J. Christie, R. S. Downe, E. T. Ruthven Murray, H. Faraday Proctor, G. Scott Ram, and C. H. Wordingham. It is proposed to hold a dinner at the Hotel Cecil on Friday, January 20th, at 7 p.m. for 7.30, the half-hour before the dinner enabling old friends to renew their acquaintanceships. There will be only one toast in addition to the loyal ones, one speaker proposing and two responding. After this it is hoped that some half-dozen "Old Stagers" will speak on their reminiscences for not more than five minutes each, and the party will then adjourn to the reception room for general conversation. All those who before December 31st, 1900, were chief engineers in municipal electrical undertakings or who were assistant engineers—electrical or mechanical—before that date and who at any subsequent time became chief engineers, are eligible to attend. Further particulars may be obtained from Mr. C. H. Wordingham, 7, Victoria-street, Westminster, S.W. 1.